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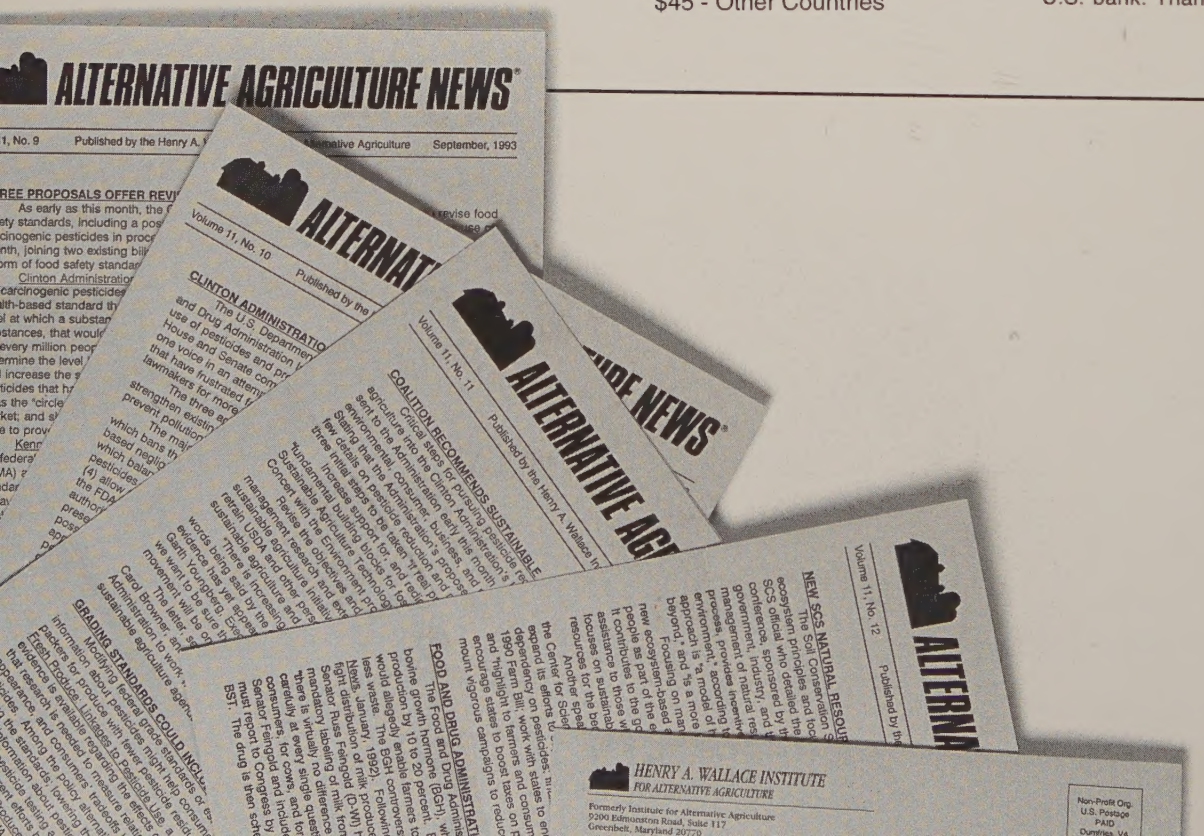

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Cover Photo

Massachusetts cranberry beds held under "late water," an extended spring flood to reduce insect and disease pressures. Photo provided by Anne L. Averill, University of Massachusetts at Amherst.

Flooding in cranberry to minimize insecticide and fungicide inputs

Anne L. Averill, Martha M. Sylvia, Charles C. Kusek, and Carolyn J. DeMoranville

Abstract. *A traditional flooding practice showed promise for reducing pesticide use in Massachusetts cranberry beds. The 4-week long spring flood, termed "late water," checked pressure of two of the most prevalent and severe management problems, cranberry fruitworm (CFW) and fungal fruit rots (CFR). Fruit rot generally was equal or lower and infestation of fruitworm was consistently lower at the late water beds compared with unflooded beds, even though no fungicides were used for CFR control (standard practice is two or three applications per season) and insecticide applications for CFW were cut by almost 70%. Although there were no significant reductions in yield in two of the years studied, a significant decline (about 25%) occurred on late water beds in one year for unknown reasons.*

Key words: *Acrobasis vaccinii* Riley, cranberry, cultural control, flooding, cranberry fruit rot, cranberry fruitworm

Introduction

In the northeastern United States, cranberry (*Vaccinium macrocarpon* Aiton) is a woody perennial vine grown in managed beds built in or next to wetlands. Historically, management of cranberry pests, particularly insects, hinged on the cultural practice of periodic flooding of the beds. Franklin (1928) opens the authoritative bulletin "Cape Cod Cranberry Insects" with the assertion that "a plentiful water supply for flooding whenever necessary is a good and cheap insurance against insect injury on cranberry bogs and should be provided when not prohibitively expensive." He recommended fall floods for management of some cutworms, particularly false armyworm (*Xylena nupera* Lintner) and cranberry blossomworm (*Epiglaea apitae* Grote), summer floods for control of white grub (*Phyllophaga anxia* LeConte), and brief floods in late spring to check blackheaded fireworms (*Rhopobota naevana* Hubner) and gypsy moth (*Lymantria dispar* L.) (Franklin 1928, 1948a). Every third season, following removal of the winter flood (used to protect the cranberry vines from injury by severe winter weather), 30-day spring floods from mid-April to mid-May were advised for management of cranberry fruitworm (*Acrobasis vaccinii* [Riley]), southern red mite (*Oligonychus ilicis* [MacGregor]), and the early season cutworms, false armyworm and cranberry blossomworm. These long spring floods, called "late water," also were widely used to suppress fungal diseases of the fruit, enhance berry quality, and extend the shelf life of harvested berries (Wilcox, 1943; Franklin, 1948a). Besides flooding, growers also used sanitation practices, botanical insecticides, and fungicides of mineral origin. Dramatic change occurred in the 1950s with the appearance of chlorinated hydrocarbon insecticides and synthetic organic fungicides, leading to heavy reliance on synthetic compounds as the sole form of insect and disease control. The improved berry quality and longer shelf life achieved with late water became less important as cranberry production moved from a largely fresh fruit market to a processing market for juice.

Within current Massachusetts Integrated Pest Management (IPM) programs, the broad range of cranberry arthropod pests and plant pathogens continue to be managed predominantly with chemicals. Effective microbial substitutes are available against an array of early season foliage-feeding lepidopteran larvae, and entomopathic nematodes can be used against some soil insects. However, no commercially effective, biorational substitutes are available against three key insect pests: cranberry weevil (*Anthonomus musculus* Say), *Sparganothis sulfureana* Clem., and cranberry fruitworm. Of these, cranberry fruitworm is the most widespread and severe problem (Brodel, 1987). Following adult emergence and egg laying in June and July, the developing larvae feed on the flesh of three to six cranberries and then overwinter in silken hibernacula. Pupation occurs in late spring (Franklin, 1948a). IPM records reveal that the insecticides currently are applied mainly against cranberry fruitworm.

The fungal fruit rots of cranberry are caused by many different pathogens. Rots commonly referred to as early or field rots include early rot, bitter rot, blotch rot and viscid rot (Eck, 1990). Other fruit rots, including end rot and black rot, develop in storage. Not all fungi causing the various rots are present at once and populations vary from year to year. Rot incidence is determined by bed conditions, such as previous history of infection and particularly by weather (temperature, humidity, and rainfall). Most infection occurs during bloom and early fruit development. IPM records

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show that most fungicide applications currently are made against fruit rot.

Cranberry production in the northeastern United States occurs in environmentally sensitive wetland areas. Also, in Massachusetts many commercial beds are in heavily populated coastal areas. Furthermore, pesticide use in cranberry production raises several serious concerns in common with many other crop production systems: the environmental consequences of pesticide use; development of strong insecticide resistance; loss of registered compounds; pesticide residues on fruit; and appearance of damaging new insect pests because of elimination of natural enemies. Together, these factors are leading cranberry producers toward strategies for reducing pesticide use. To this end, we have been investigating both novel tactics of management and traditional strategies, particularly flooding. In this study, we quantitatively evaluated the impact of late water flooding, defined above, on both cranberry fruitworm and fruit rot pressure. Such floods can be implemented on many but not all beds (we estimate 80%). Furthermore, late water management is recommended for only one year out of three because of its effects on plant growth (Franklin, 1948b). However, we reasoned that this alternative to chemically based management for both cranberry fruitworm and fruit rot could lead to immediate reductions in synthetic pesticide use in the flood year where it can be implemented. The primary objective of these studies was to establish, under current cranberry production conditions, a quantitative base to confirm historical anecdotal reports regarding the merits of the late water flood. A positive outcome would justify a more extensive, multi-year investigation of the effect of flooding, particularly on yield, but also on weed control and the possibility of reducing fertilizer inputs.

Materials and Methods

Effect of late water on cranberry fruit rot

We evaluated the effect of a late water flood on fruit rot levels in the 1988 and 1989 growing seasons. The cultivar 'Howes', which makes up about 40% of Massachusetts plantings, typically is more resistant to both field and storage rot than the cultivar 'Early Black' (about 45%) (D. Farimond, USDA Cranberry Marketing Committee, E. Wareham, MA, private communication, 1995). Therefore, we studied these cultivars separately. In 1988, we studied six pairs of Early Black beds and two of Howes beds, and three pairs of Early Black beds and four pairs of Howes beds in 1989. Paired beds were managed by the same grower and were either adjacent or within 0.5 km of each other within the same bog system. For each pair of beds at a given site, late water was held on one and early water on the other. Here, early water is defined as a bed where the winter flood was removed in March and no further flooding was carried out.

The late water beds received no fungicide applications, whereas the early water beds received two or three applications, depending on cultivar and the bed's history of rot pressure. In September, all fruit were sampled in 30×30-cm plots at four random sites on each bed. From these samples we estimated yields and assessed levels of field rot (immediately) and storage rot (after the fruit had been held in refrigerated storage for 6-8 weeks).

Effect of late water on cranberry fruitworm

In 1992 and 1993, respectively, five and eight pairs of beds, at different sites were selected to evaluate the effect of the late water flood on CFW populations. In 1992 at three of the five sites, and in 1993 at five of the eight sites, the paired beds were adjacent or less than 0.5 km apart within the same bog system. In both years, the remaining pairs were managed similarly by the same grower, had the same cultivar and bed size, had similar histories of yields and population levels of CFW, and were within 3 km of each other.

The 1992 studies were preliminary, leading to more intensive work in 1993. In 1992, berries were sampled for cranberry fruitworm eggs only during peak moth flight, whereas in 1993, berries were sampled every 5 to 7 days from the onset of adult fruitworm emergence until the end of moth flight, with an average of four samplings per bed. At each sampling, 1000 berries were randomly picked per site. From several years of earlier work, we have found that this intensity of sampling provides good estimates of absolute population levels. Fruitworm eggs in berry samples were then counted microscopically in the laboratory. In 1992, these were the only data collected. In 1993, grower cooperators were given egg infestation data and made independent spray decisions. The action threshold is 1% egg infestation of berries. At harvest, we also calculated the percentage of infested fruit by picking all berries in 10 randomly selected 30×30-cm plots per ha, and grower cooperators provided spray records and fruit yield. Data were subjected to analysis of variance; all percentage data were arcsine-transformed before analysis (Sokal and Rohlf, 1981).

Results

Effect of late water on cranberry fruit rot

Late water treatment generally was effective in suppressing fruit rot infection (Table 1). In 1988 field rot generally was greater on the late water beds (but not significantly so) than on the fungicide-treated early water beds, and storage rot was at comparable low levels at all but a single Howes pair. For this pair, the storage rot was significantly higher at the late water bed (1.2 vs. 0.2%). The total rot level was not significantly different within any pair. In contrast, in 1989, for both the Early Black and Howes cultivars there was significantly more field rot at the early water beds when all sites were combined (Early Black: 2.7 vs 0.6%, $p<0.01$; Howes: 3.5 vs 1.3%, $p<0.05$). This trend was consistent at six of seven sites, all except a Howes site, where the field rot levels were the same. Storage rot was greater in 1989 than in 1988, and for most paired beds the levels were similar.

Effect of late water on cranberry fruitworm

In both 1992 and 1993, mean infestation of cranberry fruitworm at peak flight, as measured by percentage of fruit sampled that contained an egg, was 1/9 to 1/13 as great on late water beds as on early water beds. In 1992 the percentage of berries containing an egg at peak infestation was 0.38% for the five late water beds and 4.94% for the early water beds. Again, in 1993 mean egg infestation was very low on

Table 1. Mean yields and fruit rot levels, 1988 and 1989, by cultivar and treatment.

Site	Water Treatment	Yield (t/ha)	Rot (%) Field	Rot (%) Storage	Rot (%) Total
		1988			
Cultivar: Early Black					
1	Early	21.9	0.7	0.0	0.7
	Late	20.4	1.5	0.8	2.3
2	Early	26.5	1.9	0.4	2.3
	Late	24.3	1.7	0.4	2.1
3	Early	30.8	0.6	0.6	1.2
	Late	35.1	1.9	0.3	2.3
4	Early	30.3	0.9	0.3	1.2
	Late	25.8	3.0	0.7	3.8
5	Early	24.8	0.2	0.9	1.1
	Late	35.4	0.7	0.2	0.9
6	Early	30.8	0.6	0.7	1.4
	Late	27.9	1.7	1.0	2.7
All	Early	27.6	0.7	0.5	1.2
	Late	27.7	1.7	0.6	2.3
Cultivar: Howes					
1	Early	42.1**	0.8	0.2*	1.0
	Late	21.7	2.7	1.2	3.9
2	Early	24.9	3.5	1.0	4.5
	Late	27.0	4.6	0.9	5.5
All	Early	33.5	2.1	0.6	2.8
	Late	21.8	3.6	1.1	4.7
		1989			
Cultivar: Early Black					
1	Early	15.1	3.4*	1.1	4.5
	Late	9.8	0.0	0.7	0.7
2	Early	28.0	2.3	0.9*	3.3
	Late	25.9	1.0	3.7	4.7
3	Early	34.3*	2.4	1.5	3.9
	Late	21.7	0.9	1.9	2.8
All	Early	25.8**	2.7**	1.2	3.9
	Late	19.2	0.6	2.1	2.7
Cultivar: Howes					
1	Early	8.0	2.2	0.8	3.0
	Late	12.4	0.1	1.2	1.3
2	Early	24.5	9.2	7.8*	17.0*
	Late	18.9	4.2	1.8	6.1
3	Early	36.1	0.1	0.7	0.9
	Late	27.1	0.1	1.6	1.7
4	Early	36.2*	2.5	1.1	3.6
	Late	15.0	0.7	0.6	1.3
All	Early	26.2*	3.5*	2.6	6.1*
	Late	19.3	1.3	1.3	2.6

* and ** indicate significant differences between treatments within pair (same site, cultivar, and year), at $p<0.05$ and $p<0.01$, respectively (F test, ANOVA).

late water sites (Table 2). At peak, the infestation rate on the late water beds was significantly lower than on the early water beds (0.52% versus 4.92%). The 1993 raw data (not shown) revealed that egg density exceeded the action threshold of 1% for a single fruit sample from a late water bed, but on 11 sampling occasions at seven early water beds. Furthermore, although significantly more insecticide applications targeted CFW on early water beds (mean = 2.7) compared with late water beds (mean = 0.88), the mean levels of fruitworm damage at harvest were almost equal (0.48 vs. 0.49%, respectively) (Table 2). Four late water beds received no insecticides but suffered no loss of yield to fruitworm damage.

Effect of late water on yield

The effect of late water on fruit yield varied among years, sites, and cultivars. Table 1 shows that in 1988, late water did not significantly affect yield at any Early Black site. On the Howes beds, there was a significant decrease in yield at site 1 (more than 50%) but no decrease at site 2. In 1989, for both the Howes and Early Black beds, there was a pattern of lower yield at the late water beds (five of seven sites); the difference was significant at two sites. Overall, for both cultivars, there was about a 25% average decrease in yield when late water was used, with a range of 24 to 59% lower yield on the affected late water beds.

Discussion

Late water, a month-long spring flood, showed good promise for suppression of two key pest problems, cranberry fruitworm and cranberry fruit rot. Because late water can be used one year in three (more frequent use leads to elongated uprights with little growth from lateral buds), future work should determine whether there is continued suppression of cranberry fruitworm and fruit rot pressure in successive years following late water.

Ideally, integration of this cultural practice into the current cranberry management program every third year could greatly reduce pesticide use and lead to additional benefits such as slowing the development of pesticide resistance, lower residues on harvested fruit, and buildup of natural enemies. We are not aware of any cases where

Table 2. Mean cranberry fruitworm (CFW) infestation, damage at harvest, insecticide applications, and yield on eight paired beds, 1993.

	Early water	Late water
Berries containing CFW eggs (%)		
All fruit sampled	1.66a[1]	0.32b
At peak CFW flight	4.92a	0.52b
CFW damage at harvest (%)	0.48a	0.49a
Insecticide applications for CFW	2.70a	0.88b
Yield (t/ha)	12.7a	16.6a

[1] Means in the same row followed by a different letter are significantly different ($p<0.05$).

flooding is used for disease management, but in some crops, flooding for insect control can play a role in modern sustainable programs. In Taiwan, the sweet potato weevil (*Cylas formicarius formicarius* L.) can be almost eliminated from fields by a 2-week flood soon after harvest (Talekar, 1987). Controlled flooding of sugar cane fields is effective for wireworms (Genung, 1970), and high mortalities of larval and pupal white grub (*Ligyrus subtropicus* Blatchley) occurred with as little as 5 days of flooding (Cherry, 1984).

The mechanisms responsible for the lowered fruit rot pressure on late water cranberry beds are not known. Infection caused by inoculum from off-bed sites might be decreased because bloom is shifted to later in the season. Beaton (1953) suggested that because late water beds bloom during a drier part of the growing season, conditions are less favorable for fungal infection. Alternatively, for on-bed sources of inoculum, fungi may be killed by the flood.

The physiological underpinnings of cranberry fruitworm mortality with late water also are unknown. For blackheaded fireworm, a key pest of cranberry in Wisconsin and West Coast growing regions, Cockfield and Mahr (1992) showed that under spring flood conditions, survival of larvae was similar at two temperatures tested, 2°C and 10°C. In contrast, survival was dependent on dissolved oxygen content of the water. Only 10% of larvae survived a 3-day simulated flood when dissolved oxygen was low, compared with 90% survival where dissolved oxygen was high. In contrast, changing the temperature of simulated floods from 20°C to 25°C more than doubled the mortality of the sugarcane grub *L. subtropicus*. However, dissolved oxygen content was not measured (Cherry, 1984). Regarding cranberry fruitworm, Franklin (1928) showed that larvae generally could not endure submergence under a late water flood for longer than two weeks if the water was warmer than about 16°C. Perhaps in spring, at the time of the late water flood, overwintering larvae have broken diapause, so that when they are flooded by warm water their ensuing elevated oxygen requirements are not met by available oxygen in flood waters. The amount of oxygen dissolved in flood waters of similar depths is determined largely by temperature (Eck, 1990). Future work should evaluate the impacts of both temperature and dissolved oxygen content of the late water flood to determine the cause of larval mortality, with the goal of better predictive ability for suppressing cranberry fruitworm.

Before late water can be recommended to growers, risks must be weighed against benefits both in the year of the flood and in successive years. Clearly, additional research is needed on a broader scale to allow prediction of how flooding will affect cranberry yield. Data presented here showed that although there were no significant reductions in yield in two of the years studied, a highly significant decline in yield (about 25%) occurred in one year for no known reason. However, the mean yields with late water are still not below the state average of about 19 t/ha. Isolated years of lowered crops following late water have been observed by the one Massachusetts grower (a major supplier of fresh cranberries) who uses late water extensively (20% of his total area per year). He expects a significant crop loss following late water in about one year out of ten (J.C. Decas, owner, Decas Cranberry Co., Wareham, MA, private communication, 1992). It has also long been asserted that late-holding of the winter water generally reduces the cranberry crop approximately 10% (Franklin, 1946; Eck, 1990) because it results in fewer flowers per upright and fewer flowering uprights. Under modern cranberry cultivation practices where fertilizers, irrigation systems and abundant, high quality pollination units are available, late water may reduce yield less than previously reported.

In a perennial wetland system such as cranberry, any possible deleterious effects of late water on yield must be viewed over the long term and with a broad scope. The potential for keeping cranberry fruitworm and cranberry fruit rot pressure low in succeeding years, combined with lower pesticide costs, environmental benefits, slower development of pesticide resistance, lower potential for residues on harvested fruit, and buildup of natural enemies, may offset periodic decline in yields. Furthermore, on late water beds there is evidence that some weeds are reduced (Cross, 1987), and preliminary studies have shown that satisfactory crop and vine growth is possible on late water beds with nitrogen fertilizer input reduced by 30 to 40% compared with standard practice (DeMoranville, unpublished).

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"1997 Directory of Flower & Herb Buyers" is $7.50 from Prairie Oak Seeds, P.O. Box 382, Maryville, MO 64468-0382; (816) 562-3743.

"1997 National Organic Directory" is $44.95 plus $6 shipping/handling from Community Alliance with Family Farmers, P.O. Box 363, Davis, CA 95617; 1-800-852-3832.

"Directory of Water and Wildland Expertise," listing experts at the University of California campuses, is on the World Wide Web at http://www2.nceas.ucsb.edu:8502/exp/db/intro; contact Centers for Water and Wildland Resources, (916) 752-8070.

News from the College of Agricultural, Consumer and Environmental Sciences at the University of Illinois is available on the World Wide Web at http://www.ag.uiuc.edu/news/.

"The Fruits of Their Labor: Nitrogen Management in Stone Fruit and Almond Production," a 30-minute video, is $10 from California Dept. of Food and Agriculture, Fertilizer Research/Education Program, 1220 N St., Room A-472, Sacramento, CA 95814; (916) 653-5340.

"Implementing Pheromone Technology in the Northeast," NRAES-83, is $16; **"Farming Alternatives: A Guide to Evaluating the Feasibility of New Farm-Based Enterprises,"** NRAES-32, is $8; both are available from Northeast Regional Agricultural Engineering Service, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853; (607) 255-7654.

"Forages, Fifth Edition," a CD-ROM Companion, is $54.95 from Iowa State University Press, 2121 S. State Ave., Ames, IA 50014; 1-800-862-6657.

"Alternatives to Methyl Bromide" is available from the EPA's Ozone Protection Hotline, 1-800-296-1996; or Bill Thomas, Methyl Bromide Program, EPA, (202) 233-9179.

Conservation Options Hotline, operated by the Center for Rural Affairs, assists farmers wanting to enroll in the Conservation Reserve Program, Environmental Quality Incentives Program, and Conservation Farm Option; call (402) 994-2021.

"Dig It! Biointensive Sustainable Mini-Farming," a video, is $24.95 from John Jeavons, 5798 Ridgewood Road, Willits, CA 95490.

Alternative production systems' effects on the K-factor of the Revised Universal Soil Loss Equation

Kim L. Fleming, William L. Powers, Alice J. Jones, and Glenn A. Helmers

Abstract. *The soil erodibility factor (K) of the Revised Universal Soil Loss Equation is currently considered a constant for all soils in the same type, regardless of production practice. To examine the effect of alternative production systems on the K-factor we compared pairs of alternatively and conventionally farmed fields on a Judson silt loam (Fine-silty, mixed, mesic Cumulic Hapludolls), a Yutan silty clay loam (Fine-silty, mixed, mesic Mollic Hapludalf), and a Wann fine sandy loam (Coarse-loamy, mixed, mesic Fluvaquentic Haplustolls). Soil cores were taken from the surface 10 cm and analyzed for organic matter, permeability, structure, and texture. These data were used to estimate K-factors from a nomograph. All soils in the study had a fine granular structure. Organic matter content and permeability were significantly higher for the alternatively managed field at every location, except for no difference in permeability on the Judson soil. However, the K-factor was significantly lower for the alternative system on the Judson soil. Of all the parameters, texture has the greatest influence in determining K-factors within the nomograph, with soils higher in silt being more erodible than soils higher in sand or clay. Thus, the influences of alternative production systems affected the Judson soil to a greater degree than other textures because of its higher inherent susceptibility to erosion. This study shows that alternative production systems affect the K-factor of some soil types and can reduce soil erodibility, and therefore should be considered when developing conservation plans.*

Key words: soil erodibility, erosion, alternative systems

Introduction

Excessive soil erosion and sedimentation are concerns causing farmers, researchers, and policy makers to look at alternative production systems to better protect the soil and water resource base. Alternative systems include more intensive use of crop rotations, reduced-tillage systems to conserve residue and organic matter, substitution of organic sources of fertilizers such as animal and green manures for chemical sources, and integrated pest management and biological rather than chemical control of pests. Conventional systems for east central Nebraska (the location of this research) involve fall or spring disking, spring disking or field cultivation, planting, cultivation, and using recommended rates of inorganic fertilizers and pesticides.

Although there are cases where alternative systems have reduced erosion (Peterson and Rohweder, 1983; Reganold et al., 1987; Reganold, 1988), research is needed to enable farmers and policy makers to predict quantitatively the effect of such systems on erosion and soil erodibility. This research could take the form of examining the effect of alternative systems on the K-factor (soil erodibility) in the Revised Universal Soil Loss Equation (RUSLE). The K-factor is determined from an equation comprised of five parameters: modified silt fraction (0.002–0.1 mm); modified sand fraction (0.1–2 mm); organic matter content; structure code (1=very fine granular, 2=fine granular, 3=medium or course granular, and 4=blocky, platy, or massive); and permeability code (1=rapid: >15.24 cm/hr; 2=moderately rapid: 5.08–15.14 cm/hr; 3=moderate: 1.52–5.08 cm/hr; moderately slow; 0.51–1.52 cm/hr; 5=slow: 0.15–0.51 cm/hr; and 6=very slow: <0.15 cm/hr).

Currently, the K-factor is considered a constant for a given soil type, regardless of location or production practice. However, there is not much data to support either keeping it constant or allowing it to vary. The major argument raised by some agricultural scientists working with erosion control is that management—induced changes that affect the soil are expressed by the C-factor. However, if a practice is employed over a long period and soil properties reach a new equilibrium, it seems plausible that this new equilibrium should be expressed by the K-factor, not the C-factor.

Data collected for three years in Nebraska (Jones, 1994, unpublished) suggest that using certain management practices for a long time may strongly affect the K-factor, perhaps reducing it as much as eight-fold compared with the value presently used for a given soil type. Learning how much the different land management practices affect the K-factor within a soil type will contribute to understanding how alternative systems influence soil loss and how sustainable crop and soil management practices can reduce soil erodibility. This information has the potential of improving conservation

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plans based on the RUSLE by helping local, state, and federal agencies recognize the long-term benefits of sustainable systems so that they provide appropriate credit to producers who employ these systems and encourage others to adopt them. Also, knowing how different production systems affect the K-factor will provide policy makers with information needed to delineate erodible land better.

The objective of this research was to measure the impact of alternative production systems on the K-factor of the RUSLE and on the soil properties that determine it.

Materials and Methods

Fields studied

We selected alternative production systems using the criteria of the Organic Crop Improvement Association (OCIA) for organic farms. Parameters of the K-factor for fields managed by these systems were then compared with those of adjacent conventionally managed fields. Three pairs of fields were identified in east central Nebraska. Within a pair, the fields sampled had similar soil type, climate, and relief.

Sampling was along transects 91 m long, one in each field in the pair. In spring 1995 twelve soil samples were taken from the surface 0 to 10 cm in the inter-row, non-wheel track positions of each system. In addition, twelve undisturbed soil cores, 15 cm in diameter and 5 cm long were taken and transported to the laboratory for permeability measurements.

The first pair was on a Judson silt loam soil in the northeast corner of Butler County. The alternatively managed field was originally cultivated in 1876 and has been under continuous production by the same family for 119 years. The field was managed without inorganic fertilizers and pesticides since 1972 and has been certified organic by the OCIA since 1987. Since 1972 an eight-year crop rotation has been used that consists of oats (*Avena sativa* L.), three years of alfalfa *(Medicago sativa* L.), corn (*Zea mays* L.), soybean (*Glycine max* [L.] Merr.), corn and soybean. A ridge-till system was in place for the past six years. Before that, conventional tillage was employed. The conventional field of the Judson pair has been in cultivation for over 100 years, with the current producer farming it for the past 45 years. Inorganic fertilizers and pesticides were used sporadically since the early 1950s at the producer's discretion. A rotation of sorghum (*Sorghum bicolor* [L.] Moench) and soybean is currently used with conventional tillage.

The second pair was on a Yutan silty clay loam in northeast Saunders County. The alternative field has been in production since the turn of the century. It was converted to pasture during 1960–1970, and the current producer has farmed it since 1970. No inorganic fertilizers or pesticides have been applied since 1983. The field was in a corn-soybean rotation before being planted to grass in 1960. Since 1970 the field has been in an eight-year rotation of corn-soybean-corn-soybean followed by four years of alfalfa. A ridge-till system is employed on the field. The conventional field has been managed by the current producer using a corn-soybean rotation since 1968. Recommended rates of inorganic fertilizers and pesticides have been applied on it since the late 1940s. The field was no-till in 1994 and 1995; conventional tillage was used before that.

The third pair was on a Wann fine sandy loam soil in northwest Douglas County. The alternative field has been in production for 85 years, with the current producer farming it for 60 years. Recommended rates of commercial fertilizers and pesticides were first applied in the late 1940s and early 1950s, respectively. The field has not received any inorganic fertilizers or pesticides since 1967 and was certified organic in 1985 by OCIA. Composted manure is applied every three to four years at a rate of 20 Mg/ha. An eight-year rotation is used consisting of oats/red clover (*Trifolium repens*)-corn-soybean-wheat (*Triticum aestivum* L.)-soybean-corn-soybean-corn. The conventional field has been in cultivation since the early 1900s, with the current producer having grown continuous corn since 1970. Commercial fertilizers and pesticides were first applied in the 1960s.

Soil analysis

The five K-factor parameters were determined from the soil samples and undisturbed soil cores. These parameters include modified silt fraction (0.002–0.1 mm), modified sand fraction (0.1– 2 mm), organic matter, structure, and permeability. We measured particle size by the hydrometer method (Bouyoucos, 1951; Klute, 1986). The sand fraction was retained and sieved to calculate the modified sand and silt fractions. We measured organic matter using the Walkley-Black method (1934). Soil structure was characterized qualitatively and coded in consultation with local Natural Resources Conservation Service staff as outlined in Soil Survey Staff (1993a). Permeability was taken as the saturated hydraulic conductivity of the undisturbed soil cores (Flannery and Kirkham, 1963). Numerical permeability classes for use in the K-factor equation were then determined from Soil Survey Staff (1993b). We calculated the K-factor using the RUSLE software program (Soil and Water Conservation Society, 1995).

We used analysis of variance and two-sample paired t-tests (SAS Institute, 1990) to evaluate paired differences in organic matter, permeability, sand, silt, and the K-factor. Because permeability values were not normally distributed, we logarithmically transformed these data before the statistical analysis.

Results and Discussion

Alternative production systems' effects on K-factor parameters

Soil texture. Soil texture is an inherent soil property, not directly affected by management system. Thus, texture should be comparable within pairs to allow for legitimate comparisons of K-factors. As seen from Table 1, the fractions of modified silt, sand, and clay were similar within pairs.

Soil organic matter. At all locations, soil organic matter levels were significantly higher in the alternative fields than in the conventional fields (Table 2). The alternative systems' use of crop rotations that include alfalfa and close seeded crops could be a major contributor to these differences (Hageman and Shrader, 1979; McGill et al., 1986). Within the Judson pair, differences in organic matter could also be attributable to the reduced tillage system employed on the alternative field (Carter, 1986; Doran, 1987). The more intense tillage system employed on the conventional field of the Judson pair could deplete organic matter (Bauer and Black, 1981; Aguilar et al., 1988). Tillage systems within the Yutan and Wann pairs were similar.

Table 1. Fractions of modified sand, modified silt, and clay (%) for paired alternative (Alt) and conventional (Conv) fields on three soil types.

Pair	Field	% Sand	% Silt	% Clay
Judson	Alt	3.2	72.9	23.9
	Conv	1.7	73.9	23.6
Yutan	Alt	2.5	67.8	29.7
	Conv	2.0	66.3	31.7
Wann	Alt	38.4	49.1	12.5
	Conv	36.6	51.8	11.5

Table 2. Organic matter, permeability, permeability code, K-factor, and structure code for paired alternative and conventional fields on three soil types.

Pair	Field	OM (%)	Perm. (cm/hr)	Perm. Code	Struc. Code	K-factor (t-hr MJ^{-1} mm^{-1})
Judson	Alt	3.4a[1]	5.8a	2	2	.041a
	Conv	2.6b	7.7a	2	2	.045b
Yutan	Alt	3.3a	64.0a	1	2	.031a
	Conv	2.9b	23.9b	1	2	.033a
Wann	Alt	2.3a	20.1a	1	2	.031a
	Conv	1.6b	7.0b	2	2	.041a
Mean	Alt	2.9a	30.0a	1	2	.034a
	Conv	2.4b	12.9b	2	2	.040b

[1] Means within a pair of fields in the same column followed by the same letter are not significantly different at $p < 0.05$.

Soil Permeability. Alternative fields on the Yutan and Wann soils had significantly higher permeabilities than the conventional fields (Table 2). The average permeability of all alternative fields was significantly higher than the conventional fields (Table 2). Higher organic matter levels in alternative fields could contribute to higher permeability levels. The larger amounts of decomposing organic residues tend to increase aggregate stability (Angers and Mehuys, 1988) thus increasing water infiltration (Blevins et al., 1983). Although we did not quantify it, earthworms and earthworm holes appeared more abundant in the alternative soil cores, which also could lead to higher permeability (Ehlers, 1975). The Judson soil was an exception, with the conventional field appearing to have more earthworm channels, but with no significant difference in permeability compared with the alternative field. This, along with the reduced tillage system used on the alternative field of the Judson soil, could lead to the similarity between alternative and conventional fields. Other research has shown that reduced tillage systems can reduce permeability (Gantzer and Blake, 1978; Lindstrom et al., 1981; Heard et al., 1988).

Soil structure. No significant differences were seen in the structure code used to determine the K-factor. All fields had fine granular structure in the surface 10 cm. The structure code used for all calculations in this study was 2. Although the structure code is the same in all fields, it is included in Table 2 for the reader who is interested in performing K-factor calculations.

Alternative production systems' effect on the K-factor

All the alternative fields had higher organic matter and, except for the Judson soil, higher permeability. However, only the Judson soil showed a significantly lower K-factor for the alternative field (Table 2). Overall, the mean of the K-factors for all alternative fields was significantly lower than for all conventional fields (Table 2).

A major reason for these differences could be the particle size distribution in the various fields. In general, soils that are high in modified silt, low in clay, and low in modified sand are the most erodible. Usually a soil type becomes less erodible with a decrease in the silt fraction regardless of whether the corresponding increase is in the sand fraction or clay fraction (Wischmeier and Mannering, 1969). The Judson silt loam soil was significantly higher in silt than the Yutan silty clay loam or the Wann fine sandy loam (Table 1). Thus the Judson had a higher inherent erodibility. This may explain why organic matter content and permeability affected the K-factor more for the Judson soil, so that the K-factors were significantly different between alternative and conventional fields.

Compared with published values (Soil Survey Staff, 1994a,b,c), the Judson and Wann soils had higher K-factors for both the alternative and conventional fields, while the Yutan soil had lower values for both fields (Table 3). The K-factors for the Judson and Wann soils on alternative fields did not exceed the published values by as much as the conventional fields.

Conclusions

Alternative production systems significantly affect the soil parameters used to determine K-factors in the RUSLE. Organic matter levels and permeability values were significantly higher for alternative systems at all locations in the study, except permeability values for the Judson soil. However, these higher organic matter and permeability values did not translate into significantly lower K-factors for all soils, yet K-factors were significantly lower on average for alternative production systems.

Texture plays a major role in soil erodibility. Soils higher in silt tend to be more erodible than soils high in sand or clay

Table 3. K-factor: Published values and calculated values for alternative and conventional fields on three soil types.

	K-factor (t-hr MJ^{-1} mm^{-1})		
Pair	Publ.[1]	Alt	Conv
Judson	.037	.041	.045
Yutan	.042	.031	.033
Wann	.026	.031	.041

[1] Soil Survey Staff (1994a,b,c).

(Wischmeier and Mannering, 1969). This was reflected in this study, with the Judson soil showing a significantly lower K-factor for the alternative production system. However, the differences in K-factors between the alternative and conventional fields of the Yutan silty clay loam and the Wann fine sandy loam soils were not significant at the 0.05 level, primarily because of their lower silt content.

This study shows that the K-factor varies within a soil type and that alternative production systems can reduce soil erodibility and erosion. However, the benefits of alternative production systems can affect medium-textured soils (those higher in silt) more than soils with other particle size distributions. Fleming (1995) calculated that alternative fields on the Judson and Yutan soils also had lower predicted erosion rates than the conventional fields and that the average predicted erosion for all alternative fields was significantly lower than the average for all conventional fields.

Further research is needed over multiple years and sites to confirm the initial results of this study. If later studies confirm that a variable K-factor is warranted for a given soil type because of long-term management, the technical guides used for conservation compliance planning may need to be adjusted accordingly.

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Suppression of VAM fungi and micronutrient uptake by low-level P fertilization in long-term wheat rotations

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Abstract. *The long-term effects of cropping practices on plant-available micronutrient concentrations in soils of the northern Great Plains of North America have not been adequately determined. We measured micronutrient uptake by wheat in a crop rotation experiment established at Lethbridge, Alberta in 1911. Phosphorus application at low rates (20 kg P ha^{-1} yr^{-1}) since 1972 suppressed uptake of Zn, Cu, and Ca in the two years in which they were measured, 1991 and 1993. Vesicular-arbuscular mycorrhizal (VAM) fungi are plant symbiotic fungi that are known to increase the uptake of relatively immobile micronutrients such as Cu, P, and Zn. The functioning of these fungi is known to be affected by high-levels of P fertilization. Assessment of wheat roots showed that low-level P fertilization had significantly reduced the length of root colonized and the percentage of roots colonized by VAM fungi. The results show the importance of considering microbial ecology when assessing the effects of agricultural practices, including low-input practices, on soil productivity and crop nutrient value.*

Key words: vesicular-arbuscular mycorrhizal fungi, P fertilizer, micronutrients, long-term studies, crop rotation

Introduction

The productivity and quality of soils in the northern Great Plains region of North America are significantly affected by the management systems imposed on the soil. Long-term cropping experiments have shown that crop rotations, summer fallow, and fertilizer applications influence the soil's organic matter content and quality, biological activity, and physical properties such as aggregation (Biederbeck et al., 1994).

Despite many comprehensive evaluations of such long-term treatments, their influence on the availability of micronutrients to plants has not been adequately considered. Mahler et al. (1985) observed significant effects of tillage and rotation on the distribution of extractable Fe, Zn, Cu, and Mn in a 10-year study. Follett and Peterson (1988) similarly observed significant differences in extractable micronutrient concentrations among tillage treatments. Few studies, however, have reported direct measurements of micronutrient uptake by crops in long-term studies.

Vesicular-arbuscular mycorrhizal (VAM) fungi are known to increase the mineral nutrition of plants (Ojala et al., 1983; Raju et al., 1987), in particular the less available nutrients such as Cu, Zn and P. This occurs through the uptake and transport of these nutrients via extramatrical hyphae to their plant hosts (Cooper and Tinker, 1978; Kothari et al., 1991), which increases their concentrations in plant tissues. The decrease in plant concentrations of Zn from high concentrations of P fertilizer (Singh et al., 1986), and the reduction in colonization by VAM fungi (Amijee et al., 1989; Vivekanandan and Fixen, 1991; Thomson et al., 1992) have been well documented in the field. These studies have also shown reduced micronutrient uptake and infection by VAM fungi under high rates of P fertilizer. With the increasing demands for low-input agriculture and increased biodiversity it is appropriate to study the effects of low rates of P fertilization on VAM fungi and micronutrient uptake. Jackson et al. (1993) speculated that the primary reason for the low (5–13 kg/ha) P requirement for wheat under zero-tillage was that VAM fungi were significantly contributing to the P content of the crop.

Our objectives were to determine how rotation and fertilizer treatment influence the plant availability of micronutrients and to evaluate the interaction between VAM fungi, low-level P fertilizer (20 kg/ha) and micronutrient uptake by spring wheat (*Triticum aestivum* L. var. 'Lancer') in a long-term experiment.

Materials and Methods

The experiment, done at the Agriculture and Agri-Food Canada Research Centre at Lethbridge, Alberta, was established in 1911 to compare the productivity of three rotations: continuous wheat (W), fallow-wheat-wheat (FWW), and fallow-wheat (FW). The original experiment included six 0.6-ha plots, one for each phase of the rotations (Janzen, 1995). N and P fertilizer subplots were superimposed in 1967 (0 and 45 kg N/ha) and 1972 (0 and 20 kg P/ha) to

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produce a factorial arrangement of four fertilizer treatments on each main plot. The soils at the site are predominantly Orthic Dark Brown Chernozems (Typic Haploborolls) developed under mixed grass prairie vegetation on glacio-lacustrine deposits, about 1 m deep, overlying glacial till with a pH of 7.2 (Janzen, 1995).

In fall 1991 we obtained grain samples from four 0.9-m^2 subplots of each of the 16 cropped treatments (four fertilizer by four rotation phases) in a grid arrangement. These samples were ground and analyzed by wet digestion and plasma arc spectrophotometry (Saskatchewan Soil Testing Laboratory, Saskatoon) for the following elements: Na, P, K, S, Ca, Mg, Cu, Fe, Mn, Zn, and B.

The effect of crop rotation and fertilizer treatment on nutrient concentration in the grain was determined by analysis of variance (GLM procedure, SAS Institute Inc., 1989). Although treatments within replicates were not randomized, we assume that the large spatial separation of the "blocks" (50 m) minimized the compromises associated with the analysis of variance.

We examined the effect of P fertilizer application on VAM fungi in 1992 by comparing the colonization of wheat roots in the unfertilized and P-fertilized treatments of the second phase of the FWW rotation. Roots were washed free of soil, dried at 70°C for 48 hours, and weighed. A 0.05 g subsample of the roots was cleared and stained (Phillips and Hayman, 1970) and length of root colonized by VAM fungi was assessed using a modification (Zak and Parkinson, 1982) of the line-intercept method (Newman, 1966) at 150x magnification. We subjected the VAM fungi and root data to a one-way analysis of variance following square root transformation.

In 1993, we applied 5 l/m^2 of Benomyl at a concentration of 3.5 g/l to one subplot in each of five pairs of 1-m^2 subplots in each of the control and P-only plots of the second phase of the FWW rotation. Benomyl is a commercially available fungicide that has been used in field studies to inhibit colonization of roots by VAM fungi (Fitter and Nichols, 1988; Sukarno et al., 1993). Tap water was applied at the same rate to the other subplot in each pair. The paired subplots were equally spaced along a transect centered and running the length of the main plots.

At the end of the growing season we removed six plants from each pair of subplots to a soil depth of 20 cm. The remaining aboveground biomass was removed from the 1 m^2 area and put into bags to determine dry weight and yield. The shoots from the individual plants were added to the aboveground biomass later. Roots from individual plants were washed free of soil and dried at 70°C for 48 hours and then cleared, stained, and assessed for colonization by VAM fungi as described before. We analyzed the data statistically by two-way ANOVA (StatView II 4.5, Abacus Concepts, Inc.) with respect to P fertilizer and Benomyl.

The grain samples were ground and analyzed by wet digestion and plasma arc spectrophotometry (Alberta Soils and Animal Nutrition Laboratory, Edmonton, Alberta) for Na, P, K, S, Ca, Mg, Cu, Fe, Mn, Zn, and B. Data were statistically analyzed by two-way ANOVA (GLM procedure, SAS Institute Inc., 1989) with respect to P fertilizer and Benomyl.

Results

We observed few consistent effects of treatment in 1991 on the uptake of elements other than P, Cu, and Zn. As mentioned in the introduction, VAM fungi are believed to be involved in the uptake of these particular micronutrients. We therefore present results only on these three nutrients (Table 1).

The largest differences in the concentrations of P, Zn, and Cu were always observed in response to P fertilization (Table 1). As anticipated, P application consistently increased grain P concentration. Conversely, P application significantly reduced the concentration of Cu and Zn in the grain. When

Table 1. Influence of long-term crop rotation and fertilizer application on concentration and uptake of P, Cu and Zn in wheat grain in 1991.

	Fertilizer		P		Cu		Zn	
Rotation	N	P	g/kg	kg/ha	mg/kg	g/ha	mg/kg	g/ha
W	0	0	3.6	7	4.9	10	38	79
	45	0	3.8	9	5.0	12	43	103
	0	20	4.5	10	3.7	8	31	68
	45	20	4.5	12	3.4	9	22	62
FW	0	0	4.0	11	3.9	11	27	76
	45	0	3.9	11	3.9	11	29	80
	0	20	4.0	13	3.2	10	21	68
	45	20	4.0	12	3.2	10	20	62
FWW	0	0	3.9	9	4.6	11	34	77
	45	0	3.6	9	4.8	12	38	95
	0	20	4.1	13	3.2	10	20	62
	45	20	4.0	14	3.0	10	19	67
FWW	0	0	3.8	10	4.4	11	36	91
	45	0	3.8	10	4.8	13	40	106
	0	20	4.3	10	3.7	9	26	63
	45	20	4.5	13	3.3	10	23	68
significance	(F value)[1]							
rotation	(R)		-	9***	7***	-	27***	-
N rate	(N)		-	8**	-	-	-	7*
P rate	(P)		47***	70***	111***	14***	232***	64***
	R*N		-	4*	-	-	-	-
	R*P		7***	4*	3*	-	5**	-
	N*P		-	-	-	-	20***	7**
	R*N*P		-	-	-	-	-	-

[1] *, **, and *** indicate significance at $p<0.05$, $p<0.01$, and $p<0.001$, respectively.

averaged across treatments, the Zn concentration in P-fertilized treatments was only 66% that of the treatments receiving no P (23 vs. 35 mg/kg). Similarly, average grain Cu concentration in P-treated soils was only 71% that of treatments receiving no P (3.3 vs. 4.6 mg/kg).

Evaluation of wheat in 1992 showed that the length of roots colonized by VAM fungi was significantly lower in the P-fertilized than in the unfertilized treatment (Table 2). Analysis of soil from a plot in the FWW rotation in 1986 showed that bicarbonate-extractable inorganic P was higher in the P-fertilized subplot (16 mg/kg) than in subplots receiving no fertilizer (8 mg/kg) (McKenzie et al., 1992). These concentrations were considerably lower than in other studies reporting reduced VAM infectivity in response to P fertilizer (Thomson et al., 1986; Amijee et al., 1989).

Benomyl inhibited the colonization of roots by VAM fungi, but it also appeared to interact with the soil in so many complex ways that it was not possible to conclude anything from the data. It also appeared that the formulation contained high concentrations of some micronutrients we were analyzing. Therefore, we will present only the data collected from both the P-amended and control subplots that were not treated with Benomyl. We reanalyzed the data using a one-way analysis of variance to examine the relationship between P fertilizer and micronutrient uptake in wheat plants.

The results from 1993 agree with those of the previous year: concentration and uptake of P increased and the Zn concentration decreased in response to low-level P fertilization. P fertilization significantly affected concentration and uptake of Mn and Ca in 1993, but not of Cu (Table 3). Dry grain yields in 1993 were 2.3 Mg/ha in the unfertilized and 3.1 Mg/ha in the P-fertilized plot; in 1993 they were 2.2 Mg/ha in the unfertilized and 2.1 Mg/ha in the P-fertilized plot. It is most likely that the difference in yield between 1991 and 1993 in the P-fertilized plot represents the variation in subplot sampling, because there was a consistent response of grain P and Zn to P fertilizer application. There were more and longer roots in 1992 compared with 1993 (Tables 2 and 4). However, the percentage of roots colonized by VAM fungi and the response of the fungi to P fertilizer were similar in both years, as were root weight, total root length, root length colonized, and percentage of roots colonized by VAM fungi. Once again, colonization by VAM fungi was significantly inhibited by low level P amendment in 1993 (Table 4).

Table 2. The effects of phosphorus amendment on shoot and root dry weights, total root length, and root length colonized by VA mycorrhizal fungi in spring wheat in 1992 (n=10).

	Annual P Rate (kg/ha)		
Parameter	**0**	**20**	**Signif. (p)**
shoot weight (g)	6.2	8.8	ns
root weight (g)	0.13	0.22	0.01
total length (m)	3.3	4.5	0.10
colonized length (m)	1.2	0.6	0.10
% colonized	32	14	0.01

Discussion

In 1991, N fertilizer and crop rotation significantly affected P, Zn, and Cu uptake, but differences could largely be explained by yield response (Jarrel and Beverly, 1981). For example, application of N increased yield, thereby increasing the uptake of P and Zn. Similarly, yield was higher when wheat was grown after fallow (F<u>W</u> and F<u>W</u>W) than after wheat (<u>W</u> and FW<u>W</u>), resulting in the dilution of Zn within the grain. Uptake of Cu and Zn was not affected by rotation. Consequently, there was no evidence of any consistent long-term effect of crop rotation on availability of Zn or Cu.

The lower concentrations of Zn and Cu in P-fertilized treatments cannot be attributed to a dilution effect because total uptake of these nutrients into the grain also was significantly suppressed (Tables 1). In 1991, P application tended to increase yield, whereas Zn uptake was significantly lower in P-fertilized treatments (mean 65 g/ha) than in treatments receiving no P (88 g/ha). Corresponding means for Cu uptake were 9.5 and 11.4 g/ha, respectively.

In 1993 the concentration and uptake of Zn and Ca were lower in the P-fertilized treatment, whereas P and Mn were significantly higher (Table 3). These findings are consistent with other reports that have shown that VAM fungi increase the shoot content of micronutrients (Raju et al., 1987; Kothari et al., 1990, 1991) particularly Zn (Kucey and Janzen, 1987; Mohammad et al., 1995). Our study shows that VAM fungi and low-level P-fertilization may also affect the nutrient content of grain. However, there was no evidence that the suppression of Ca, Cu, and Zn uptake by P fertilization induced a yield-limiting deficiency of these

Table 3. The influence of long-term crop rotation and fertilizer application on P, Cu, Zn, Mn, and Ca concentration and uptake of wheat grain in 1993 (n=15).

P rate	P		Cu		Zn		Mn		Ca	
(kg/ha)	g/kg	kg/ha	mg/kg	g/ha	mg/kg	g/ha	mg/kg	g/ha	mg/kg	kg/ha
0	3.7	8.2	5.9	12.9	29.4	64.9	41.3	92.2	97	21.6
20	4.4	9.4	6.0	12.6	26.8	53.9	48.7	101.0	90	18.3
	Significance (F value)[1]									
	11.3**	2.8*	NS	NS	NS	4.3**	8.6***	NS	6.3**	4.3*

[1] *, **, ***, **** indicate significance at p<0.1, p<0.05, p<0.01, and p<0.001, respectively.

Table 4. The effects of phosphorus amendment on shoot and root dry weights, total root length, and root length colonized by VA mycorrhizal fungi in spring wheat in 1993 (n=15).

	annual P rate (kg/ha)		
Parameter	0	20	signif. (p)
shoot weight (g)	15.0	14.2	NS
root weight (g)	0.063	0.096	0.001
total length (m)	1.4	1.3	NS
colonized length (m)	0.4	0.1	0.001
percent colonized	27	10	0.001

nutrients. Differences in rainfall and temperature from year to year affect plant growth and thus plant uptake and content of micronutrients, as reflected in our field study. The consistent effect of low-level P fertilizer on Zn uptake and concentration of grain in both years shows the direct effect of VAM fungi on Zn concentration and uptake in grain, which is consistent with other reports (Kucey and Janzen, 1987; Singh et al., 1988; Amijee et al., 1989; Mohammad et al., 1995). Our observations were limited to two years; nevertheless, the presence of Zn deficiencies under other conditions cannot be entirely discounted.

Other studies have reported suppression of Zn and Cu uptake and concentration by high rates of P (Lambert et al., 1979; Lambert and Weidensaul, 1991; Singh et al., 1986, 1988) and lower uptake of Mn in mycorrhizal plants (Kothari et al., 1991). This effect of P has been attributed to decreased translocation of Zn from roots to shoots (Singh et al., 1988) and to the suppression of VAM fungi by high levels of P (Lambert et al., 1979; Singh et al., 1986; Amijee et al., 1989; Lambert and Weidensaul, 1991). Increased uptake of Ca in response to VAM fungi also has been reported (Ojala et al., 1983); however, it is likely that the increased concentration of Ca is an indirect effect of increased colonization by VAM fungi (Kothari et al., 1990). Changes in root physiology can be accompanied by VAM colonization of host roots (Clapperton and Reid, 1992). The increase in organic and amino acids in the roots of VAM colonized plants (Clapperton and Reid, 1992) also may partially explain the increase in Ca and decrease in Mn uptake and concentration of the more VAM colonized unfertilized wheat. Acidic root exudates may act to release more cations such as Ca^{2+} from the soil while making more P available for plant uptake (Jurinak et al., 1986) which in turn can displace some Mn.

In both 1992 and 1993, plants sampled from the low-level P fertilized plot had significantly more root weight and less root length colonized by VAM fungi than plants from the unfertilized plot (Tables 2 and 4). The effect of P on root weight probably reflects the P nutrient status of the plant. Decreased root growth has been reported when plants are exposed to either very high or low P levels in combination with VAM fungi (Abbott and Robson, 1984; Kothari et al., 1991). The lower root weight and lack of effect on the total root length in the unfertilized treatment compared with the P-fertilized treatment suggests that either VAM fungi or low-level P is altering root morphology, with a corresponding shift in root physiology.

Our experiment provides evidence that even low rates of P (20 kg ha^{-1} yr^{-1}) applied over a long period can appreciably alter the microbial dynamics in agricultural soil and influence crop nutrition and micronutrient value of grain. The results of this experiment also show the importance of considering microbial ecology when assessing the effects of agronomic variables on soil productivity.

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Organic Sales Increase by 26 Percent in 1996

Sales of organic grocery and dairy products increased by 26 percent in 1996 to a total of $3.5 billion in sales, an increase from $2.8 billion in sales in 1995, according to *Natural Foods Merchandiser* (June, 1997). Last year marked the seventh consecutive year organic sales increased by at least 20 percent; exports and direct sales increased from $714 million in 1995 to $872 million in 1996.

The best-selling category of organic food was grocery and dairy, with $633 million in sales; organic dairy sales alone accounted for $120 million, an increase of about 50 percent in 1996. Frozen and refrigerated foods accounted for $283 million; bulk products, $242 million; herbs, $191 million; bakery, $117 million; produce, $89 million; and miscellaneous, $395 million.

Sales of "natural products," which include organic foods and beverages, dietary supplements, and all-natural personal care products, increased by more than 25 percent in 1996 to $11.5 billion; 1995 sales were $9.17 billion. Last year was the fourth consecutive year the natural products industry reported double-digit growth.

Organic market expansion has been strong for several reasons, according to *Natural Foods Merchandiser.* There are more convenience and gourmet items being offered; there is more and varied produce; and more restaurants are featuring organic offerings. Distributors also cite a geographic expansion —"there is greater interest, and new accounts, in cities away from typical organic hotbeds," according to the magazine.

A separate article in *Kiplinger's Personal Finance Magazine* (July, 1997) asked if a higher grocery bill for organic foods guarantees "better nutrition, taste, or safety." It concluded that "nobody has ever been able to show that organic food is any better nutritionally than any other food," but that "whether organic foods are safer depends on which danger you're trying to guard against." Organic meat and poultry are leaner, which makes them "healthier," the article said.

World Food Prize Seeks Nominations

The World Food Prize seeks nominations for the 1998 prize, with a deadline of December 31. The prize is the highest individual honor for outstanding achievement in improving the world's food supply, and recognizes achievements in any field involved in the world food supply, including food and agricultural science and technology, manufacturing, marketing, nutrition, economics, political leadership, social sciences, and other related fields.

The prize emphasizes the importance of a nutritious and sustainable food supply for all people. For nomination applications, contact David Acker, World Food Prize, Office of the Secretariat, College of Agriculture, 104 Curtiss Hall, Iowa State University, Ames, IA 50011; (515) 294-2883; e-mail bjelland@iastate.edu.

A farmer-centered approach to developing information for soil resource management: The Illinois Soil Quality Initiative

Gerry Walter, Michelle Wander, and Germán Bollero

Abstract. *The Illinois Soil Quality Initiative (ISQI) is a multidisciplinary effort to develop accurate, practical, and meaningful measures of soil characteristics that farmers can incorporate in strategies to sustain soil resources over the long term. We discuss how the project integrates soils and social research and involves farmers and others in guiding its research activities. A board of farmers, farm managers and conservation agency personnel and a panel of soil scientists, agronomists, and social scientists established ISQI's goals and monitors its progress. ISQI technical staff gather data at 35 participating farms to assess the accuracy and practicality of several measures of physical, chemical, and biological characteristics of soils under varying tillage and environmental conditions. They communicate findings to farmers and the ISQI board through regional farmer meetings, a project newsletter, and statewide conferences. Participating farmers assess the measures' meaningfulness and practicality, suggest strategies for communicating soil quality information, and recommend new directions for research. These observations have been made at the end of ISQI's first year: definitions of and beliefs about soil quality vary widely, making it inadvisable to think of "soil quality" as a single, inclusive concept; farmers and other land managers want to understand better the relationships among soil qualities, productivity, and sustainability, and to learn how to enhance their soils' structural and biological characteristics; soil quality measures must be accompanied by research and education on how soil qualities are affected by management practices or systems and how they affect yields and the environment; many farmers are only mildly interested in self-administered soil quality measures, preferring instead to purchase such data from commercial sources.*

Key words: on-farm research, participatory research, sustainable agriculture

Soil Quality and Sustainability

The Board on Agriculture of the National Research Council (1993) recently recommended that the nation "conserve and enhance soil quality as a fundamental first step to environmental improvement." The Board also recommended making the concept of soil quality—the natural combination of physical, chemical, and biological attributes that underlie the soil's potential utility—the guiding principle for agricultural policy and practice.

However, while soil quality is easy to conceptualize, it has proven difficult to measure (Doran and Parkin, 1994; Doran et al., 1996). The additive and site-specific nature of soil quality is not easily translated into measurable parameters, and it is even less clear how the concept of soil quality can be translated into agricultural practices, policies, and regulatory statutes. Furthermore, every soil's value depends upon its users' goals, perspectives, and concerns.

Nonetheless, growing public interest in protecting soil quality (National Research Council, 1989) suggests that key soil quality indicators need to be identified and made the basis for monitoring and predicting changes in soil quality (Granatstein and Bezdicek, 1992; National Research Council, 1993; Acton and Gregorich, 1995). Farmers also need reliable indicators of tractable soil qualities to know how their management practices affect soil and water quality and to fit new stewardship standards into their already complex decision-making processes. As environmental regulations and incentives change, farmers will require soil monitoring technologies that make clearer the environmental outcomes of different farming systems.

Research to define useful soil quality indicators has been directed at how and what to measure, and has not gone beyond technical discussions or lists of variables. Thus, while the concept of soil quality has clear value as an educational and regulatory tool, the current approach to soil quality research is not likely to produce results helpful to farmers trying to identify combinations of production practices that will protect or enhance the soil resources on their own farms (Doran, 1995). New research and problem-solving formats are needed that go beyond the technical classification of soils to merge the ideas, concerns, and interests of all who have a stake in preserving the soil's economic, biological, social, and cultural potentials. We present a problem-solving format designed to help reconceptualize soil quality's role in land management and link it to information systems that effectively interpret and deliver research findings to those who would use them.

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The Illinois Soil Quality Initiative

The Illinois Soil Quality Initiative (ISQI) is a collaborative effort of farmers, farm managers, conservation professionals and researchers to turn information about an array of soil attributes into technologies useful for making soil and farm management decisions. The project's primary objective is to identify accurate, practical, and meaningful soil quality measures and assessment methods that farmers and other agricultural land managers can use in selecting specific management practices and systems. These measures are also likely to prove useful in other contexts where land management affects or is affected by soil quality, such as the valuation of farmland and the targeting and evaluation of environmental policy measures. ISQI research is examining a range of soil characteristics under different management systems on 35 commercial farms in Illinois and is evaluating the reliability of currently available measures of soil attributes.

Fundamental to ISQI's strategy is an effort to identify which soil qualities and measurement procedures have meaning and practical utility for farmers and other land managers. Because ISQI's objective is development of technology rather than transfer of existing technologies, the project relies on a collaborative process in which farmers' experience-based appreciation of soil quality measures and their place in farm decision making is constructively merged with scientists' construct-based analyses of the measures' utility. In this process, farmers and other nonscientists actively guide research and interpret research findings. Throughout the process, participants' needs are the principal criterion against which project activities are measured. Researchers and technicians also participate by managing the data collection, analysis, and reporting.

Promise and Problems of On-farm and Participatory Research

Agricultural producers and society in general are struggling with increasingly demanding assessments of farming system performance, not only by such customary measures as profitability, productivity, and efficiency but also by a system's contribution to environmental sustainability and the quality of farm and community life (Lockeretz, 1987; Miller, 1990; Thornley, 1990; Cardwell, 1991). For this reason, producers seek research-based information, hoping to apply it to decisions and problems they experience on their own farms (Lockeretz and Anderson, 1990; Thornley, 1990; Watkins, 1990). Farmers seeking this kind of information can be frustrated by research whose primary purpose is to test hypotheses and refine theories (Ikerd, 1993). Yet much agricultural science is focusing on increasingly narrower aspects of plant and animal development rather than whole system functioning (Busch and Lacy, 1983).

Practical arguments for on-farm participatory research

Typical "component" research is poorly equipped to answer questions of overall farming system performance. Component studies simplify complex systems to isolate a limited set of processes for analysis, imposing controls on "extraneous" variables or conditions (Breimyer, 1991). But phenomena observed in controlled research settings are not consistently observed in practice, where they are often confounded by the complex social and biological interactions that constitute farming systems. Component research often controls the very conditions—including the timing and precision of management tasks—whose variation is critical to a farming system's environmental as well as economic performance (Suppe, 1987). Consequently, component research often fails to address producers' questions about the performance of technologies on their own farms and within the contexts of their own farming systems. For the same reasons, component research often cannot furnish answers to policy makers, interest groups and others concerned about environmental and social outcomes attributable to farming systems as a whole.

Critics also assert that much agricultural research is oriented more toward satisfying scientists' disciplinary interests than producers' specific needs for knowledge. Because scientists are rewarded for publishing findings of interest to their scientific disciplines, they avoid or neglect research on problems for which there is not likely to be a single, optimal solution (Cardwell, 1991; Ikerd, 1993). Limited resources for adaptive research also prohibit intensive study of single productive units to answer site-specific questions. Consequently, even research aimed at answering farmers' questions may yield recommendations, inferred from findings from research plots or several farms, that fit no actual farm (Suppe, 1987; Ikerd, 1993).

On-farm studies, particularly those done at the field or farm scale, often incorporate variations in soils, weather, and management skills, and therefore provide a more realistic setting than is possible in station research. Experimental designs have been suggested that enable farmers and others engaged in on-farm research to enhance the validity of their findings without the cost and cumbersomeness of the randomized designs typical of scientists' smaller-scale experiments (Rzewnicki et al., 1988; Thompson and Thompson, 1990). On-farm study of suites of practices likewise can allow more accurate observation and assessment of farming system performance than is possible in less natural settings (Lockeretz and Anderson, 1990).

Producer participation in framing research questions also promises to make research more responsive to farmer needs. Arguing for a "farmer first" approach, Bunch (1990, p. 149) claims that "technology developed by farmers on farmers' fields will often have more credibility than that developed by researchers on research stations" and that close farmer-researcher contact will keep research priorities aligned with farmers' needs. Similarly, Bawden (1989) says that sustainable development requires researchers and farmers to work together in a problem-solving, knowledge-generating system. Not only does such collaboration help solve immediate farming problems, he says; it also improves both researchers' and farmers' practice and critical understanding.

The ethical argument for participatory research

Cardwell (1991) notes that any research dealing with agricultural systems must acknowledge agricultural technology's human aspects—the social, economic, and cultural conditions that constrain and channel the development and deployment of technologies for managing physical and biological

processes. Research to develop effective management technologies therefore necessarily requires researcher-farmer interaction and collaboration. Successful research efforts, he says, require that farmers believe they have been treated fairly, have been heard and given credence, and have been co-creators of problem solutions that were not imposed from outside.

Krippendorff (1986, 1989) elaborates the broader ethical and epistemological arguments for making scientists and nonscientists equal participants in all aspects of the research process. He questions both the ethics and the validity of research that treats study participants (e.g., farmers) as "trivial machines" who respond to external stimuli predictably and without freedom. Similarly flawed, he says, is much social and behavioral research that aims to explain human behavior using group or class membership, economic rationality, or other constructs not directly observable or understood by those supposedly governed by them. Researchers who adopt this "objectivist" stance, he says, use the people they study to further their own ends but return little that is meaningful to them.

Rather, he argues, scientists have a moral obligation not to deal with other humans as instrumental to their own goals, or at least to allow them to negotiate the terms of their instrumentality. Furthermore, human behavior, including farming, cannot be adequately understood by detached observation alone; real understanding requires scientist-participant interaction characterized by mutual respect for one another's divergent interests and specialized knowledge. The understanding produced in such a relationship is created jointly and is specific to the interaction—in the research process, researchers change and are changed by those they study—and cannot be produced any other way.

Problems in participatory research

On-farm and participatory research strategies do not by themselves produce such ethically negotiated farmer-researcher relationships, nor do they assure that research will answer system-level questions. Valid conclusions about system-related outcomes require either whole-farm comparisons or complex multivariate designs that substitute statistical control for the more customary physical controls of component research (Thompson and Thompson, 1990; Thornley, 1990). Academic researchers must perceive rewards for themselves, which means choosing research that adequately answers disciplinary as well as farmer questions. Yet if scientists unilaterally establish both the research question and the design, farmer participation becomes trivial and the study effectively becomes station research done on the farm.

On the other hand, strict "farmer first" strategies (Rhoades and Booth, 1982) can focus too narrowly on farmers' own immediate information needs, overlooking questions farmers fail to ask. Such studies can fail to address root causes of the symptoms that farmers have defined as problems. Farmer-first models also may fail to use scientific expertise and insight to full advantage (Roling, 1988; Lockeretz and Anderson, 1990). With soil quality, farmers may not be familiar with measures of the physical and biological properties of soils and therefore may be unprepared to frame research questions that include them. This also poses problems in making such measures meaningful: practical on-farm use for soil structure information does not yet exist. Furthermore, farmers typically lack on-farm facilities for reliably analyzing and interpreting soil characteristics, and therefore cannot manage soil research without technical assistance from scientists.

The ISQI Research Framework

ISQI's chief objective is to identify and develop measures of biological, physical and chemical characteristics of soils that are meaningful to farmers and other soil resource users and that are practical to use and sufficiently accurate for their potential users' needs. ISQI activities are structured to permit soil quality measures and indexes to be assessed according to these criteria and to involve scientists and farmers in developing a research agenda that increases their understanding of soil quality's meaning, both practical and scientific. Three primary groups direct and conduct ISQI activities: a board of farmers, farm managers, scientists, environmental organization representatives and conservation professionals that gives broad direction to ISQI research programs; farmer participants who make their farms available for data gathering and interpret project findings and suggest potential uses for them; and a core group of scientists and technicians who gather, analyze, and report data to the board, participating farmers, other researchers, and the public.

General project design

The ISQI project frames a broad social question—are agricultural uses of soils influencing soil quality?—as a research question through an experimental design that quantifies farming system effects on soil properties and separates the effects of landscape features from those of land management. Rather than focusing on small plots or imposing experimental treatments, ISQI studies farm fields of 40 acres or more under mainstream production practices, pairing them with adjacent areas that are largely undisturbed. To minimize the influence of spatial and temporal variability of soils within fields, ISQI samples soil at nine sites within each field. By identifying more precisely the sources of variability in soil measures, ISQI is quickly able to observe trends in soil properties attributable to land use. This design also enables ISQI to ask questions about system performance in an on-farm study and to produce data that have meaning both for society and for individual farm managers.

ISQI participants and stakeholders have different needs and uses for soil quality information. Making ISQI research findings meaningful for all potential users therefore requires that they be interpreted and reported in ways appropriate for varying uses and levels of understanding. The ISQI framework incorporates a communication research component to assess participants' information needs, potential information uses, and preferred information formats. It also uses a recursive evaluation and planning process so that project activities will better meet participants' varied needs for accuracy, practicality, and meaning. Project research staff analyze and interpret data, then share findings for individual farms, regions and land-use practices with cooperating farmers, who help interpret the data and explain apparent anomalies. Farmers further direct the researchers' efforts by asking questions and suggesting solutions to anticipated problems. The ISQI board also reviews project findings, integrates them with

participants' goals, and reframes ISQI research questions according to emerging or changing needs and goals.

ISQI Activities

Setting objectives: The ISQI board

To identify major issues and concerns in the various contexts in which soil quality indicators might be used, ISQI planners invited a group of farmers, scientists, and representatives of local, state, and federal organizations to serve on a board that would assess the project's accomplishments and direct its activities. Table 1 lists the occupations and organizations of initial ISQI board members. This board first met in December 1994 to review the project's proposed objectives, add and delete measures to be tested, indicate desired uses for soil quality information, and establish procedures for communicating with ISQI researchers. Board members also explored the philosophical, social, practical, and technical aspects of the soil quality question (some of their remarks appear in Table 2). At a second meeting, board members adopted a working definition of soil quality for the project similar to that proposed by Doran and Parkin (1994): soil quality is the capacity of soils within landscapes to sustain biological productivity, maintain environmental quality, and promote plant and animal health.

Following the second ISQI board meeting, ISQI planners defined the project's three primary research activities: an on-farm research program to compare and refine a suite of soil quality indicators under different management systems; a pilot study to evaluate the reliability of a range of measures of soil attributes; and a communication research program to identify needs and potential uses for soil quality information. The research team named a project manager to coordinate research activities and a communications manager to maintain contacts among the ISQI board, research team, farmer participants, and interested members of the public.

Before field work began in 1995, the research team also used the board's comments to refine the soil quality measures and methods to be evaluated in the on-farm and pilot studies. The final list of soil variables (Table 3) included physical, chemical, and biological measures selected from the minimum soil quality data set (Larson and Pierce, 1991; National Research Council, 1993) and Doran's Soil Health Kit (Cramer, 1994).

Table 1. Illinois Soil Quality Initiative board and staff.

ISQI Board

Farmers (5)

Farm managers (4)

Organizations
- Illinois Sustainable Agriculture Soc.
- Sierra Club
- Midwest Sustainable Agriculture Working Group
- Illinois Stewardship Alliance
- Landmark Agricultural Conservation and Environmental Center
- Conservation Technology Info. Center
- Illinois No-Till Farmers Assoc.
- Illinois Society of Professional Farm Managers and Rural Appraisers
- U.S. Department of Agriculture
  - Soil scientist

University of Illinois
- On-farm research coordinator
- Field station agronomist
- Soil scientists (2)
- Geographer
- Agricultural engineer
- Graduate student
- Research specialist, farm and research management
- Plant pathologist

Natural Resource Conservation Service
- Soil scientists (2)

Illinois Cooperative Extension Service
- Crop systems educator
- County unit leader

ISQI Research Team (Univ. of Ill.)
- Soil ecologist
- Farming systems research specialist
- Communication/rural sociologist
- Research/extension specialist

ISQI Research Cooperators (Univ. of Ill.)
- Biometrician
- Soil Physicist
- Agronomist
- Pedologist
- Soil fertility specialist
- Microbiologist

Evaluating accuracy and practicality: The on-farm study

The ISQI on-farm study is a two-year effort to compare soil quality measures under different management systems in working fields. During February and March 1995, the ISQI project manager recruited more than 50 farmer participants, and from these selected 35 fields according to soil type, cropping history and topographic region. All fields had been in a corn-soybean rotation under conventional (disc, moldboard plow or chisel plow) or reduced tillage (no-till) management for at least five years. Each combination of crop and tillage (conventional corn, conventional soybeans, no-till corn, no-till soybeans) was represented by at least two fields in each of the three topographic regions. Each field also had an adjacent area available for sampling that was at most only slightly disturbed, such as a fence row, pasture, yard, or cemetery.

Farmer cooperators agreed to permit data collection in the field twice per year during 1995 and 1996, to furnish a five-year or longer management and yield history for the field, and to attend a winter meeting to help investigators interpret the findings from the field. In return, they received detailed reports of soil data taken from their fields and were paid $150 each.

From June through November 1995, ISQI technicians gathered soil samples and other data at nine points in each field and from the undisturbed area near each field. Soil samples were analyzed at University of Illinois laboratories, where data on the status of each measure were prepared for each participating farmer. Impacts of tillage and region on soil variables were identified by multivariate analysis of variance to compare the different management systems' possible effects on various soil measures.

Calibrating measures: The pilot study

The ISQI pilot study evaluates the accuracy of the measures used in the on-farm

study in the more controlled setting of long-term, replicated tillage trials. At university research stations in each of the on-farm study's three topographic regions, ISQI researchers are making the same measurements as in the on-farm study. They also are evaluating a set of "farmer-oriented" soil quality measures (Table 3) on agricultural plots and, where feasible, in adjacent undisturbed locations. Data from these measures will be compared with those from the on-farm study. In 1996, the pilot study began testing exploratory or alternative measures of soil biological activity.

Making sense: The ISQI communication research project

This project identifies farmers' soil quality information needs and gathers data needed for effectively collecting, interpreting and communicating soil quality information. During summer and fall 1995, project staff individually interviewed 34 farmers (including 16 on-farm study cooperators) and 17 professional farm managers. Preliminary interview protocols were tested with two farmers and one farm manager. Final interview protocols were similar for both groups, though the farmer protocol included more detailed, probing questions. The main interviewer was a former professional farm manager.

Each interview began with informants explaining their own conceptions of soil quality and soil health. Using a modified sense-making procedure (Dervin, 1983, 1984), interviewers then asked informants to describe in detail the steps that led them to a recent choice of tillage practice or other decisions related to soil quality, the specific questions they faced at each step, the sources they turned to for information to answer each question, and the adequacy of the information they found there. Informants also described whether and how they might use additional soil quality indicators and their preferred format and channel for receiving such information. Interviews were audio-taped and transcribed for analysis and reporting back to project participants.

Table 2. A sample of soil quality perspectives offered by ISQI board members.

Current statements about soil health and sustainable productivity tend to romanticize the concept rather than being founded on factual scientific research. This creates polarized opinions in people. The question is really economic: What, if anything, are we doing to our soils that is wrong, and how can we improve productivity and sustainability and still be economically viable?
Gary Johnson, Hutchinson Farm Management

Soil quality and soil health concepts provide many opportunities useful to the Natural Resources Conservation Service in accomplishing its mission of helping people conserve, improve, and sustain our natural resources and environment. A general assessment of soil quality provides an overall view of the food, fiber, and feed production capabilities of the nation and the state. Eventually, a set of soil health indicators will be added to the NRCS field office technical guides. The effects of the recommended conservation practices on soil health can then become integral in developing integrated farming system plans.
Bob McLeese, State Soil Scientist, Natural Resources Conservation Service

When we ask about how agricultural practices may impact soil quality in Illinois, we presume that 'soil quality' has value, that soil is a resource to be protected. Since here we are concerned about soil as a medium for growing crops—itself a vital, dynamic process—'soil health' in some ways is a better term for our inquiry than 'soil quality.' We want to be able to protect and enhance the soil capability with regard to fertility and nutrition. The processes at work include those physical and biological tendencies and interactions.
Jack Norman, Council for Food and Agricultural Research

We will never have a completely satisfactory definition of soil quality. To the farmer, soil is his factory. And he wants to know anything he can about making his soil better, about improving his factory.
Leon Kohlmeyer, grain and livestock farmer

I'm not sure a term like 'soil quality' is needed. We've long recognized the importance of soil productivity. We recognize that soil fertility is part of productivity, and we've devised soil tests for it. Somehow with the term 'soil health,' we're thinking about a check-up and doing soil tests for things we may not be able to manage for our well-being. Thus, this is embarking on a different way of soil management that we haven't shown is significant for our well-being.
Ted Peck, Univ. of Ill. professor of soil fertility

It will not be enough to agree on terminology that enables us to contrast the condition of one soil with that of another. The more important question for the long term is: How does the condition of the soil compare to the condition of the same soil, say, ten, twenty, or fifty years in the past or future? Acceptable management of the soil should clearly reflect our knowledge, obtained both from experience and from science, and a social imperative that our soils will function in perpetuity.
Dave White, Univ. of Ill. agriculture and farm management research specialist

Expanding the data base: NRCS cooperation

During 1995 ISQI became a partner in the National Soil Quality Institute of the Natural Resources Conservation Service (NRCS). In August 1995, Illinois NRCS personnel began collecting soil survey information on all farms in ISQI's on-farm study, using the Pedon program (Doll, no date) to interpret soil profile descriptions. NRCS pedologists also are sampling soil at each location to provide soil series descriptions and, using a system developed by Grossman et al. (1995), are assessing "use-invariant" soil properties at one agricultural and one undisturbed location in each field. The NRCS measures are listed in Table 3.

These data will be merged with NRCS morphological descriptions and then linked with ISQI data. The NRCS data set emphasizes inherent soil features that change on a geological time scale. By contrast, the ISQI data describe soil features that are dynamic within a season. Merging these perspectives will help ISQI scientists identify parameters that can be used as indicators of

Table 3. ISQI soil quality measures by project component

Biological measures	*Physical measures*	*Chemical measures*
On-Farm Study		
Soil respiration	Infiltration	pH
Particulate organic matter	Penetrometer	Available N
Surface residue	Macropores	N mineralization potential
Microbial biomass	Bulk density	
	Soil moisture	Nitrate in profile
	Aggregation (dry-distribution)	Phosphorus
	Wet aggregate stability	Base cations
	Soil type	Cation exchange capacity
	Soil texture	Conductivity
		Total C & N
Pilot Study		
(Farmer-Oriented and Reference Measures)		
Earthworms	Infiltration	pH (pocket meter)
Spring NO_3 exchange (membrane)	Rooting depth	Dispersible clay
	Nitrate test strips	
NRCS Use-Invariant Properties		
Morphological description	Restricting layer	Macropore description
Aggregate strength	Crusting	Soil texture
Profile description		

management impacts occurring over a few years. Cooperation with NRCS also links ISQI with a key farmer source of technical assistance for soil management.

Keeping in touch: ISQI newsletter

From the outset, ISQI planners anticipated a publication that would maintain communication with project participants, build identity for the project, and promote attendance at meetings and conferences. In December 1995, the first ISQI newsletter was mailed to ISQI board members, participating farmers, and other interested individuals and organizations. This four-page tabloid included articles about the project's goals, objectives, and component programs, an on-farm study progress report, and announcements about upcoming activities. Two subsequent newsletters have included additional reports on ISQI activities and findings, including summaries of the soil quality views held by communication project participants.

Reporting back: Winter meetings

In February 1996, the ISQI research team met with participating farmers and local extension and NRCS staff at half-day meetings in four regions of the state. Attendees included about 40% of the participating farmers in each region. At each meeting, ISQI scientists presented findings from the first year of on-farm data collection. All farmers also received written reports of the findings from their own fields. Farmers and ISQI personnel then engaged in a focused discussion of the ISQI soil quality measures' meaningfulness for farm management decision making, the likelihood that participants would use the measures in their own decision making, whether the measures should be developed as procedures farmers could do themselves or as additions to conventional commercial soil tests, and other information needed to make the information summarized by the measures more meaningful. Each discussion was audio-taped and transcribed for analysis. A sample of comments from the meetings appears in Table 4.

Recharting the course: 1996 ISQI board meeting

The ISQI board met again in March 1996 to hear progress reports from the research team and reports on winter meeting activities by participating farmers. The board discussed problems experienced with specific on-farm study measures and suggested alternative or corrective measures. This was followed by a discussion of ways to make project data meaningful for farmers and the types of technologies the project should be developing.

A Work in Progress: ISQI at 18 Months

ISQI's primary objective is to develop accurate, practical, and meaningful technologies to enable farmers and others to monitor the status of various biological, physical and chemical aspects of soil quality. The criterion of meaningfulness also requires that these measures yield information about the soil quality effects of different crop production and soil management systems, information that farmers and others can use when choosing production systems to meet their economic, environmental and other goals. Underlying the framework are the practical and ethical objectives of involving soil managers in selecting research questions and methods, interpreting findings, shaping development of soil measurement technologies, and in other ways guiding project activities toward joint problem solving.

After one year of data collection, ISQI research efforts have begun to show progress toward these goals. With its multiple and repeated measures in many fields under a narrow range of management systems, the on-farm study is yielding data about these systems' soil quality performance much sooner than would be possible using more strictly controlled designs at fewer sites. Measurements in undisturbed areas also furnish rough baseline information about each soil's native properties. A second year's data will strengthen ISQI's ability to identify relationships between broad classes of management systems and a range of soil attributes.

More important at this point, however, is that ISQI has constructively involved farmers, farm managers, conservation professionals, public interest groups, and researchers in action research that promises rewards for all. Bringing board members and researchers together before and after data collection has increased participants' understanding of each other's points of view, helped them work toward agreement on the project's goals and methods, and provided opportunities for sharing interpretations of findings from the component

Table 4. Sample of soil quality issues and perspectives expressed by farmers at ISQI winter meetings

My long-term interest is in where we stood in terms of soil quality when we started, where we stand now, and where we're going in the future. I'm also interested in the various aspects of it that we can control, whether it's with chemicals or tillage or anything else we have control over.

Economics is going to be the bottom line for the whole [preserving or improving soil quality] thing. What's it going to cost me to do this, and what am I going to get paid back for doing it?

Take the example of severely compacting my soils just to get a crop in. There's nowhere, really, that I can get an answer to how much damage I've done and how much I'm going to pay for it down the road. I'm not sure there is any information about this at this point. But that's a direction where I think the university could do some work to help us make our decisions.

I would hope that at the end of two years that you [ISQI] would tell me which soil quality tests you feel are reliable and useful. Then we farmers will move those tests into our farming system—and we'll be creative doing it.

If I can go out in my field and put a cylinder in the ground and pour water in it [a reference to an ISQI test for infiltration], and the water just stands there, well I've obviously got a problem. But until you have a practical way to find out why the water doesn't run down, what can you do about it? Maybe my water won't run down because I need to disk deeper. And maybe some other guy's water won't run down for some other reason. We may all have the same symptoms, but caused by different problems.

You might have better luck getting guys to do these kinds of [soil quality] tests if they could have a commercial service do them. A lot of operations are getting big enough that guys just don't have time to do this stuff themselves. Especially not in the summertime, when there are a lot of other things going on, if that's when the tests need to be taken.

The soil we have to work with here in Illinois is so forgiving that we can't comprehend what we've done to it. You can just abuse it and abuse it and abuse it, and it just keeps right on giving. But it can't go on forever—there is a limit. I have no idea what the limit is, and I don't pretend to know. But everything has a limit.

But just what is the [productive] capacity of any given field? I don't even know what the potential of my fields is. If I find out what that is, then how do I get to that point?

Hopefully, I can take [ISQI findings and dialogue] back to our no-till association back home and start telling people why some of the things we're doing in no-till are working, and maybe why some of the things we're doing in no-till aren't working. Then maybe we can solve some of our own problems back home.

studies. ISQI's newsletter, conferences, and winter meetings have kept participants informed about project activities, acquainted them with ISQI staff and one another, and helped keep the project in the front of their minds. Studying farmers' and farm managers' information needs, rather than specifying in advance the content and form of soil quality information to be reported, has enabled project resources to be allocated toward activities that will make ISQI most useful and meaningful.

Insights from ISQI's first year include the following:

- *Definitions of soil quality and beliefs about the relative importance of different aspects of soil quality vary widely, making it inadvisable in practical terms to think of 'soil quality' as a single, inclusive concept.* At early ISQI board meetings, members showed strong but very different ideas about the definitions of soil quality and soil health and about their potential usefulness in making crop production and environmental management decisions. Some members preferred the more holistic term soil health to the term soil quality, emphasizing the biological basis for processes of interest. Some cooperating scientists found both terms vague and non-scientific, and criticized the term 'soil health' in particular as subjective. These and other discussions led to a shift in the project's approach from seeking measures of soil *quality* as a unitary concept to development of measures of soil *qualities*, any or all of which might be incorporated in individuals' decisions about soil management practices.
- *Farmers and other land managers want to understand better the relationships among soil qualities, productivity and sustainability, and to learn how to preserve and enhance their soil's structural and biological characteristics.* Some participants at the first ISQI Soil Quality Conference expressed interest in developing soil quality measures as regulatory standards for judging and rewarding good stewardship. Others argued that soil quality measures by themselves are an incomplete and misleading measure of stewardship, given that no two farmers are likely to have begun farming with soils of identical quality. This discussion led ISQI planners to deemphasize development of soil measures for use in environmental monitoring, though ISQI participants recognize that many measures tested in the project will be useful in regulation.

  Despite their reservations about regulation, the participants were interested in obtaining information about soil properties that contribute to soil quality and wanted to learn more about using soil information to increase their farms' productive capacity. Most wanted to know how Illinois' soil had been changed by agricultural use, which led to including natural areas, prairies, and undisturbed sites in the on-farm and pilot studies. Understanding farming systems' effects on soil characteristics also was an important topic at winter meetings with cooperating farmers.
- *Soil quality measures must be accompanied by research and education that relates changes in physical and biological attributes of soils to changes in management practices and effects on yields and the environment.* During winter meetings, ISQI researchers asked farmers what they might do if ISQI data suggest their practices are diminishing soil quality on their farms. The consistent response was that if the research found such a relationship, they would

change their management systems to the extent that economic constraints would allow. However, they also pointed out that a decision to change practices or systems would require information to tell them which practices were diminishing soil quality, which they might confidently expect to enhance soil characteristics they deem important, and the magnitude of the economic and other benefits, costs and risks associated with making a change. They also proposed a long-term research agenda for exploring relationships among specific practices, soil quality, productivity, and economic performance.

- *Most farmers appear only mildly interested in soil quality measurements they can make themselves, preferring instead to purchase such data along with other commercial soil test information.* Individual farmer interviews and focused discussions at the ISQI winter meetings quickly revealed that one of the project's initial goals—development and evaluation of soil quality measures that farmers themselves could perform, analyze, and interpret—was inconsistent with farmers' information needs. Most participating farmers want additional soil information beyond the typical soil fertility analyses. But when asked if they would prefer measurements they could make themselves or those performed by others, such as soil testing services or the NRCS, they overwhelmingly said they would rather save labor by having others collect information about their soils. Therefore, farmers' use of information specialists such as private consultants and management firms is likely to continue and perhaps increase as ISQI develops more reliable soil quality measures. This finding also suggests that useful soil quality measurement technologies also will need to appeal to commercial agricultural information sources, not just farmers.

The ISQI structure thus far appears to offer a promising model for merging farmer participation with scientific expertise in applied research. An aspect of the ISQI On-Farm Study that distinguishes it from many current on-farm research designs is the reliance on researchers to collect and analyze nearly all the project's field data. Farmers are asked only to provide information about management and crop yields. ISQI's technology development goals require this division of labor in the project's early, "systems assessment" stage, when the data produced are not yet at a level useful for making management decisions on individual farms. Even so, participating farmers report that the on-farm study's field-scale findings from working (and often familiar) farms are more meaningful than those from station research.

Having the research done on their own farms enables the farmers to observe and informally evaluate the measures used to gather the data and the sites from which the data came. Most important, having farmers present in the field and in interviews and meetings to explain and help interpret the findings from their own and their neighbors' fields helps researchers draw more reliable and meaningful conclusions from the data. As ISQI moves into later stages of data collection and development of soil quality measurement technology and begins to incorporate aspects of the farmers' long-term soil quality research agenda, the shifting division of labor will find farmers more involved in data collection and the design of their own on-farm tests.

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UPCOMING EVENTS

September 22-26, National Watershed Water Quality Project Symposium will be held in Washington, D.C.; contact Conservation Technology Information Center, 1220 Potter Drive, #170, West Lafayette, IN 47906; (765) 494-9555.

September 24-25, "Working with Wetlands and Wildlife" will be held in Denver, CO; contact Wildlife Habitat Council, 1010 Wayne Ave., #920, Silver Spring, MD 20910; (301) 588-8994.

September 24-27, "The Future Agenda For Organic Trade," the 5th IFOAM Conference on International Trade in Organic Products, will be held in Oxford, England; contact IFOAM Conference, 86 Colston St., Bristol BS1 5BB, England; phone (44) 117-929-0661; e-mail soilassn@gn.apc.org.

September 24-28, "Taking Root: Building Community from the Ground Up," the 18th Annual Conference of the American Community Gardening Association, will be held in Indianapolis, IN; contact Tom Tyler, Purdue University Cooperative Extension Service, 9245 N. Meridian St., #118, Indianapolis, IN 46260; (317) 848-7351; e-mail tom@marion.ces.purdue.edu.

September 27, Fourth Annual Country Living Field Day will be held on three farms in Carroll County, OH; for information and a map, contact Ohio State University Extension, (330) 627-4310.

September 27-29, "Small-Scale Agricultural Production and Marketing for the Southwest," Part Three: "Cooperative CSA and Value Added Production" will be held at New Farms Agricultural Training Center; contact NewFarms, HC 69 Box 62, Rociada, N.M. 87742; (505) 425-5457.

October 3, "Provender Alliance's 20th Annual Conference: Cultivating Green Economics" will be held in Wilsonville, OR; contact Kathleen Downey, Provender Alliance, (541) 688-4415; e-mail provender@aol.com.

October 4, 3rd Annual PASA Harvest Festival will be held in Penns Creek, PA; contact Pennsylvania Association for Sustainable Agriculture, (814) 349-9856.

October 4, "Hoes Down Harvest Festival," the 11th Annual Celebration of Rural Living, will be held in Guinda, CA; **October 5,** Organic Farm Bus Tour will be held in Capay Valley, CA; for both events, contact Dru Rivers, Committee for Sustainable Agriculture, PO Box 222, Guinda, CA 95637; (916) 796-3464.

October 6, "Agricultural Research Institute 46th Annual Meeting: Agricultural Funding Now to Ensure Food for the Future" will be held in Rockville, MD; contact ARI, (301) 530-7122.

October 6-8, "Partnerships for Global Ecosystem Management: Science, Economics and Law," the 5th Annual World Bank Conference on Environmentally and Socially Sustainable Development, will be held in Washington, D.C.; contact the World Bank, ESSD5, Room S7-040, 1818 H St., NW, Washington, D.C. 20433.

October 7, "Sustainable Beef Management Workshop" will be held in Springfield, TN; contact Ann Wells or Ron Morrow, NCAT/ATTRA (Appropriate Technology Transfer for Rural Areas), 1-800-346-9140.

October 15-18, "Local and Global Communities: Complexity and Responsibility," the 9th International Conference of the Society for Human Ecology, will be held in Bar Harbor, ME; contact Dr. Melville Cote, Executive Director, c/o College of the Atlantic, 105 Eden St., Bar Harbor, ME 04609; e-mail sheconference@ecology.coa.edu.

October 17-19, Biointensive Sustainable Mini-Farming Workshop will be held in Waimea, HI; contact Cynthia Raiser Jeavons, 5798 Ridgewood Road, Willits, CA 95490; (707) 459-0150.

October 19-24 or October 26-31, "Herbicide Action," a course on herbicides in plants and the environment, will be held at Purdue University, West Lafayette, IN; contact S.C. Weller, (765) 494-1333; or Kathy Hyman, 1-800-359-2968 or (765) 494-2758.

International Conference on Agricultural Production and Nutrition: Abstracts and closing address

In March 1997 an international conference was held in Boston, Massachusetts, on the ways that the nutritional value and quality of foods are affected by how they are produced. It was organized by the School of Nutrition Science and Policy, Tufts University, and was attended by people from 19 countries.

The conference theme was interpreted broadly, with "quality" encompassing not only biological and chemical characteristics such as nutrient content, but also social and political consequences of different production systems. In all, 46 papers were presented, the abstracts of which are printed here, followed by the closing address. The 20 papers marked with * are included in the proceedings volume.

William Lockeretz

Regional, National and Global Issues

***Food system approaches to improving nutrition and health.** *Gerald F. Combs, Jr.,[1] Ross M. Welch[2] and John M. Duxbury.[3]*

[1]Division of Nutritional Sciences, [2]USDA Plant, Soil and Nutrition Laboratory, and [3]Dept. of Soil, Crop and Atmospheric Sciences, Cornell University, Ithaca, NY 14853.

The health, productivity, and well-being of every person depend on access to sustenance provided by food systems of varying complexity; yet these systems have evolved with little explicit attention to the quality of their nutrient outputs or their overall ability to support good health. The nexus of food production and health is nutrition, and poor nutrition diminishes the quality of life for billions of people in both developed and developing areas of the world. Incorrect nutrition contributes to problems that erode the quality of life and have substantial social costs, which makes improving nutritional status a consumer issue, a public health issue, and a national development issue.

Malnutrition affects nearly half the world's population, particularly the poor in the developing nations. Some 840 million people do not have access to enough food to meet their basic needs, and more than one-third of the world's children are stunted by inadequate diets. Some 2 billion people live at risk of diseases resulting from deficiencies of vitamin A, iodine, and iron; most are poor women and children. By potentiating infectious disease, malnutrition is thought to account for half of all child deaths. Although impressive gains have been realized in global food production, high-yielding "green revolution" varieties of staple grains have displaced traditional crops, decreasing the diversity of many cropping systems and actually contributing to micronutrient malnutrition. Better approaches are needed to meet the increasing demands of a world that expects to add 2.5 billion people over the next 25 years. Neither traditional nutrition interventions, focused on correcting nutrient inadequacies, nor agricultural policies focused on increasing production and input inefficiencies, have succeeded in solving problems of poor nutrition; the full potentials of food systems have not been exploited to these ends. Holistic food-based system approaches hold promise to providing sustainable solutions to this global nutrition conundrum.

Malnutrition not only is morally unacceptable; with an expanding global population and an internationalizing economy, its effects are inescapable. Thus, new links must be forged between nutrition, agriculture, and related food system disciplines to find sustainable solutions to malnutrition worldwide.

The need for a "greener" revolution: Linking agricultural systems to human nutrition, health and development. *John M. Duxbury. Dept. of Soil, Crop and Atmospheric Sciences, Cornell University, Ithaca, NY 14853.*

The Green Revolution coupled high-yielding crop varieties with inputs of nutrients, water, and pesticides, concentrating on cereal crops because of the increasing caloric needs of rapidly expanding populations. The resulting increases in rice and wheat production in south Asia came mostly by increasing yields. Substantial increases in per capita availability of rice occurred only in China, but cereal availability in general either has remained stable or increased, so that energy malnutrition has decreased.

A cropping system resulting from green revolution technology alternates flooded rice and wheat; this now occupies about 20 million ha, principally in India and China, and supplies staples for almost 20% of the world's population. This productive rice-wheat system has displaced other food crops, reducing the diversity in those regions. For example, rice-wheat areas have seen reductions in the production of grain legumes (pulses), which have been important sources of protein, iron, and zinc in vegetarian diets, particularly those of the poor. This has resulted in a reduction in the iron density of diets and has increased the prevalence of iron-deficiency anemia to the highest levels in the world.

Opportunities exist to alter cereal-based cropping systems, many of which are faced with the "post-Green Revolution blues,"

*The proceedings volume is available for $18 (this includes postage for prepaid orders; add $3 for orders that must be billed). Outside North America, add $10 for air mail; otherwise surface mail will be used. Payment should be made to "Trustees of Tufts College" and mailed to: Agriculture/Nutrition Conference, School of Nutrition Science and Policy, Tufts University, Medford, MA 02155.

namely, stagnating yields and decreased returns per unit of input. Seizing such opportunities calls for changing the paradigm for agriculture from a strict focus on increased production to one that marries increased production with desired nutritional outcomes from the total food system. The new paradigm must address local nutritional balance in food production as well as environmental and economic sustainability.

***FOOD 21: Integrated research on production systems, product quality, consumer and farmer aspects of sustainable agricultural production.** *Ann-Christin Bylund,[1] Rune Andersson,[2] Anders Kiessling,[1] Lennart Björck[1] and Per-Olow Sjödén[3]*

[1]Dept. of Food Science, Swedish University of Agricultural Sciences, S-750 07 Uppsala; [2]Swedish Environmental Protection Agency; [3]Centre for Caring Science, Uppsala University, Glunten, S-751 83 Uppsala.

Present Swedish agricultural production systems fail to respect several basic principles of sustainable food production. We have identified the most urgent nonsustainability issues to be: dependence on fossil energy and nonrenewable phosphorus deposits; leaching of nutrients (N and P); loss of soil fertility; accumulation of heavy metals such as Cd in arable soils; loss of biodiversity; air pollution (N_2O, CH_4, CO_2); dependence on medications in animal production; unbiological methods of animal care; and contaminants and residues in food products. Sustainability goals have been formulated for each of these, as well as for farmer acceptance of sustainable production methods and consumer acceptance of sustainably produced foods. The quality aspects to be fulfilled by sustainably produced foods have been specified in the FOOD 21 Declaration. This can be used to inform consumers about both *production* quality (corresponding to the sustainability issues above) and *product* quality (sensory, technological, nutritional, and hygienic).

The overall aim of the FOOD 21 project is to evaluate how these sustainability goals can be balanced against the requirements of quality and quantity in food production. Suggestions for both modifications of existing systems and new solutions will be made on the basis of an integration of available information and on data from research performed within the project in a few key areas. The main structure of the program consists of integrated research activities in the following areas: environmental problems in agriculture; crop and animal production systems; product quality; consumer behavior; and farmer decision processes. Systems analysis, focusing both on physical flows on the level of the farm and on decision processes among farmers and other actors in Swedish society, will be used for integration. A Synthesis Group of researchers and practitioners will perform the major task of integrating existing knowledge and suggesting novel production methods.

Preliminary suggestions for sustainable production solutions that will be tested empirically or against available literature are: integration of animal and crop production; reduced soil cultivation; supplying P through recycling; keeping animals in open and free range systems; increased grazing in preservation areas; animal feedstuffs based on national production; and optimization rather than maximization of production. Very little information exists about the various quality aspects of food items produced in organic or sustainable production systems. Also, consumer beliefs, attitudes, intentions, and behaviors have been neglected in previous research, as have factors affecting decision processes among farmers with respect to sustainable agricultural production. Thus, the project should provide new insights in these areas. The paper will include an interim report on research and integrative activities.

The role of international agencies in promoting a safe, high quality and nutritious food supply. *Gregory Orriss. U.N. Food and Agriculture Organization, Viale della Terme di Caracalla, 00100 Rome, Italy.*

The Food and Agriculture Organization (FAO) of the United Nations is the lead agency in the UN system for the promotion of agricultural policies to improve the safety, quality, and nutrient content of the world's food supply. This includes all aspects, from primary production through processing, storage, and distribution to the end consumer. Governments of developing countries are provided assistance to establish or strengthen their national food control system as well as their agricultural policies. International standards and codes of practice on food quality and safety also are provided for guidance in both the production and processing of foods.

This paper outlines the FAO activities in assisting developing nations to improve their food supply and to ensure that those foods are safe, of good quality, and nutritious. It further explores the actions taken by the FAO/WHO Joint Food Standards Programme, through the Codex Alimentarius, to establish international recommended standards of safety, quality, and identity of foods, as well as recommended codes of practice in food handling and processing.

Dilemmas in the European Union's policy for healthy food. *Niels Heine Kristensen and Thorkild Nielsen. Institute of Technology and Social Science, Technical University of Denmark, DK-2800 Lyngby, Denmark.*

The EU has recently defined the consumer's interest in food as a matter of declaring the ingredients. At the same time, other institutions and organizations have shown a growing interest in knowing the impact of the production process on the environment and health. One reason for the attitude reflected in the EU policy is the lack of a tradition of consumer and community involvement in food policy in most EU member states. But powerful industry organizations' traditional influence on EU policy also plays a major role. As a result, the EU has allowed more additives and coloring agents in food in recent years.

As a response to this development, organic farmer organizations, consumer organizations, labor unions and others for years have been promoting organic production principles. In a simplified definition, an organic production system avoids using processing aids and other additives that do not originate in organic agriculture.

Since 1991 the principles of organic agriculture and food production have been regulated by the EU (EU Council Regulation No. 2092/91). In this framework, some substances are allowed in organic production. Since the EU took over this regulation there has been a clear tendency to allow still more food additives and processing aids in

organic foods. Some member states, as well as organic farmer and consumer organizations, are opposed to these decisions.

Local and regional governments can establish stronger and more restrictive regulations. Using concrete examples from Denmark, other EU member states, counties and local authorities that promote healthful and nutritious foods, this paper discusses possibilities for expressing a policy in opposition to the EU policy. The analysis shows that small-scale and local activities can deal with this debate while observing specific preconditions.

***Regional dietary guidance: Is the Northeast nutritionally complete?** *Jennifer L. Wilkins[1] and Joan D. Gussow.[2]*

[1]Division of Nutritional Sciences, Cornell University, Ithaca, NY 14853-4401; [2]Teachers College, Columbia University, New York, NY 10027.

The diets of most Americans draw minimally on foods produced and processed locally. Since the long-term sustainability of the food and agriculture system of the northeastern U.S. is presently under threat, increases in consumer demand for locally produced and processed foods might help preserve remaining farms and processing operations. In the last few years, nutrition educators have come to view food guides and other educational materials as capable of playing a key role in achieving such local food systems.

The Northeast Regional Food Guide (NERFG) was developed to encourage consumption of foods produced and processed locally. If consumers are to be advised to eat local foods, however, the question of whether such diets are nutritionally adequate must be resolved. Two two-day menus (one ovo-lacto and one that includes animal flesh) were designed for each season using selections based on foods from the NERFG that could probably be grown in sufficient quantity in the Northeast if demand existed. The diets were analyzed for energy and nutrient content using the Nutritionist IV computer program. The results indicate that it is possible to obtain a nutritionally complete, varied diet from foods grown and processed in the northeast region.

Defining and Evaluating Food Quality

***Research and policy issues related to the nutritional quality of alternatively produced foods.** *Kate Clancy. Henry A. Wallace Institute for Alternative Agriculture, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.*

For at least 70 years researchers have been interested in the effects of production methods on the nutritional quality of foods. For at least 25 years supporters of organic agriculture have hoped that the claims of nutritional superiority would be verified for organic foods. However, despite some evidence of and theoretical bases for quality differences, valid comparisons of the nutrient composition of foods produced in conventional and alternative systems have not been made, for a variety of reasons.

Three general problem areas encompass most of the challenges to those hoping to use nutrition as a selling point for sustainable agriculture. The first is a set of technical issues. There is a dearth of scientifically sound and statistically valid studies with controlled variables. The number of variables that must be controlled is daunting, a fact not always understood. The multiplicity of variables greatly increases the complexity, costs, and number of studies that must be done.

The second concern is a lack of research interest, which is low for several reasons. Among them are the perception that this is a low priority among farmer needs, the necessity of multidisciplinary projects, the difficulties in determining the types of studies to be done and the nutrients to measure, and the high cost of nutrient analyses.

Consumer and regulatory issues are the third problem area. The level of interest in the vitamin and mineral composition of food is not strong. There also is consumer skepticism because of misleading claims and reports in the past. Not surprisingly, standards for claims or for a data bank have not yet been developed, and cannot be until many more analyses are completed.

In this paper these and related issues are described and recommendations offered as to what might be done with these problems.

Critical evaluation of complex parameters and methods for food quality assessment: What are the facts? What do they mean? *Joachim Raupp. Institut für Biologisch-dynamische Forschung, Brandschneise 5, D-64295 Darmstadt, Germany.*

Drawing on investigations in a long-term fertilization experiment, some parameters of storage ability are discussed. One of the oldest approaches to quantifying storage ability is the degradation test, in which vegetables are cut into portions or grated, then incubated, with dry matter loss, respiration, and visual changes in the samples evaluated. Degradation tests can distinguish between fertilization treatments. However, it is difficult to reproduce the results of these tests, and the results do not correlate with information gained by storage tests under optimal conditions. The degree of microbial attack seems to be the most reliable parameter in degradation tests.

The darkening of potato extract is a parameter that can reflect fertilization effects. However, the relationship of this parameter to food quality and product vitality needs further investigation. Increasing electrical conductivity of potato extract is assumed to indicate the decomposition of organic matter. However, this parameter is not specific with respect to either the substances that are decomposing or the active enzymes or organisms.

Food preference tests with animals are useful for quality assessment. Fertility of animals in feeding experiments has some importance for animal nutrition, but its relevance to humans is controversial.

In every case, quality assessment is based on human priorities, expectations, and considerations of usefulness. If it is accepted that food quality has a human, social dimension, then other political, social, psychological and economic criteria must be elaborated and considered.

***The Quality Index: A holistic approach to describe the quality of food.** *D.G. Schulz and U. Köpke. Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, D-53115 Bonn, Germany.*

The quality of food products has many aspects, and cannot be described just by single parameters. An isolated view often leads to a misleading interpretation of an analysis. Also, differences in certain parameters often

are not significant although they occur in repeated investigations. To overcome these problems, several parameters are combined into a "Quality Index." The first attempts to describe product quality with quality indexes were made in the 1970s. The index we present is a consistent development of this approach.

A field experiment was carried out using twelve ridge beds oriented east-west to study the effects of light intensity (south side with sun exposure, north side shady), with different forms of organic manuring (fresh horse manure or two-year-old composted horse manure), with and without biodynamic preparations. The following parameters were analyzed: dry matter, carbohydrates, nitrate, amino acids, protein quality, shelf life, and a morphological parameter characterizing maturity of carrots. The Quality Index was calculated from these data. The quality ranking indicated that sunlight and biodynamic preparations were able to improve quality.

An extended list of parameters will be applied to use this Quality Index in ongoing investigations with potatoes.

Development of a fully automated analysis of the riboflavin vitamers in unfortified foods. *L. Faye Russell,[1] Lydia Brooks[2] and Ken B. McRae.[1]*

[1]Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main St., Kentville, Nova Scotia B4N 1J5; [2]Agriculture and Agri-Food Canada, Laboratory Services Division, Bldg. #22, Central Experimental Farm, Ottawa, Ontario K1A 0C6.

A fully automated method is described for determining the concentration of riboflavin and its coenzymes, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) in unfortified foods. The method combines robotics with HPLC, and the results for unfortified foods that are significant dietary sources of riboflavin are comparable to those obtained by HPLC using manual extraction. The HPLC separation has previously been shown to provide total riboflavin results that are comparable to the standard AOAC international fluorometric method. The automated method provides for both unattended analysis and increased sample throughput. This permits representative estimation of mean vitamer content and inherent variability in unfortified food products with minimum personnel.

Soils, Fertilizers, and Nutritional Quality

Review of soil and human health. *Margaret A. Oliver. Dept. of Soil Science, University of Reading, Whiteknights, Reading RG6 6DW, UK.*

Human health can be affected in several ways by the soil, leading either to specific diseases or to more general ill health. Some effects are associated with the natural conditions of the soil, while others are exacerbated or brought on by people's actions, such as pollution. Whatever the cause, they need to be counteracted. Ill health can result from deficiencies of certain trace elements in the soil, from excesses of some heavy metals that enter food from the soil, from radioactive elements such as radon, from fibrous dust, and from soil wetness. The ill effects often are insidious.

There are numerous case studies and references to relations between soil and human health, but surprisingly, they are rarely reported in the literature of soil science. In this paper I review what I regard as the most important and far-reaching of them. These include the effect of cadmium excesses in the soil; cadmium accumulates in cereals in particular, and long exposure to excess cadmium results in renal damage (for example, itai-itai disease). Iodine deficiency in the soil and water was one of the first cases of a trace element linked with health; it causes goiter, hypothyroidism, and endemic cretinism. Selenium deficiency has more recently been associated with disease; it is linked with cardiomyopathy and joint problems. Excess fluoride causes fluorosis in parts of India and Africa, which affects the development of bones, for instance, whereas deficiencies have been linked with dental caries in parts of Britain. Excess lead in the soil often is a pollutant and causes intellectual impairment rather than a specific disease. Asbestos occurs in the soil in Turkey, and because of desiccation becomes airborne and is inhaled, giving rise to mesothelioma. Radon moves through the soil and then into buildings, where it concentrates and is implicated in certain malignancies, especially lung cancer.

Some of the relations between soil and health are uncertain and the causes putative, and require further research to validate them. These include the association of heart disease with poor soil, as in the glaciated regions in northern Europe and the coastal plain of the eastern United States. For other elements there are clear direct relations with the etiology of diseases. These are particularly evident when there are subsistence economies that also are isolated, with the result that most of the food is derived locally.

Soil scientists should collaborate with medical and health workers to investigate further the causes of poor health where the soil is implicated. By mapping the risk of diseases, rather then merely the cases or rates of incidence, environmental conditions in the areas of high risk can be investigated fully. Factors in the soil would form part of this research, and geostatistical methods such as disjunctive kriging would enable the risks of deficiency or toxicity to be determined in relation to particular threshold values of elements in the soil.

***Historical changes in the mineral content of fruits and vegetables: A cause for concern?** *Anne-Marie Mayer. Applebarn, Week, Dartington, Devon TQ9 6JP, UK.*

A balance of the different essential nutrients is necessary for maintaining health. The eight minerals that are usually analyzed are Na, K, Ca, Mg, P, Fe, Cu, and Zn.

A comparison of the mineral content of fruits and vegetables grown in the 1930s and the 1980s (published in the *Composition of Foods* tables) shows several marked reductions in mineral content. There are statistically significant reductions in Na, Ca, Mg, and Cu in vegetables, and K, Mg, Fe, and Cu in fruits. The only minerals that showed no significant differences over the 50-year period were P and Zn.

These findings could indicate a deterioration in the quality of food over those 50 years. Changes in agricultural practices could have contributed to the decline, such as soil compaction and cultivation, use of agricultural chemicals, disruption of soil life, or lack of organic matter. The choice of varieties of fruits and vegetables could have changed over the 50 years, with the new

varieties lower in minerals. However, the changes could have been caused by anomalies of measurement or sampling, or contamination of the samples. If not, they may point to a dominant farming system that is out of balance.

All the minerals analyzed are essential in the diet of humans. Their roles range from maintenance of the immune system to structure of bones. The paper examines these roles with emphasis on symptoms of deficiency. It concludes by recommending an investigation of the causes of the changes in mineral content and their effects on humans.

Relationship between soil quality and food quality for Ghanaian soils. *Violet A. Quayson,[1] Francis Tetteh[1] and A.B. Ankomah.[2]*

[1]Soil Research Institute of CSR, Academy Post Office, Kumasi, Ghana; [2]University of Science and Technology, Ghana.

The continuous nutrient depletion of Ghanaian soils renders their fertility status perilously low. To support the ever-growing population with adequate agricultural produce, agriculturists are faced with the challenge of improving soil fertility status to adequate levels for sustainable production.

Soil is the major natural resource, and needs to be well studied and properly managed to sustain human, plant, and animal life. Its quality encompasses temperature, pH, moisture, structure, consistency, microorganisms, nutrients status, and other factors. Soil quality and prevailing environmental factors directly affect the quantitative and qualitative variation of plants and their products. Whatever nutrients the soil does not have the plants will not get, and ultimately animals and human beings will lack them also.

Crop quality is relative, depending strongly on the purpose for which the crop is cultivated. Crop quality can be expressed in many ways: market value, nutritive value, and physical value. The inherent genetic composition of a crop plays a significant role in its quality. When soil nutrients are favorably balanced for a particular crop, its quality improves considerably. Soil nutrients are always in flux, with additions and removals. Making the right type and quantity of nutrients available to the plants at the right time is highly significant for the quality of plants and their products.

Currently, there are several nutrient management systems for the study of soil nutrient dynamics. A few cases have been studied in Ghana for some crops. These studies indicate that fertilizers are one of the most effective and fastest-acting ways to change the chemical composition of plants and to improve crop quality. The agronomist should be knowledgeable and must apply knowledge skillfully. In each case, one must take into consideration the role of individual nutrients in the life of plants, their biological characteristics, the basic pattern of plant metabolism, and the properties of fertilizers.

***Soil remineralization for sustainable agriculture.** *Joanna Campe,[1] Tara A. O'Brien[2] and Allen V. Barker.[2]*

[1]Remineralize the Earth, Inc., 152 South Street, Northampton, MA 01060; [2]Plant and Soil Science Dept., University of Massachusetts, PO Box 30910, Amherst, MA 01004-0910.

Dusts from finely ground or washed glacial moraines and other hard silicate rocks contain a broad spectrum of mineral elements beneficial for plant growth. Soil remineralization is the utilization of these dusts to restore soil fertility through replenishment of plant nutrients removed by agricultural activities or by forces of nature.

Research was initiated in 1996 to assess remineralization of soils for vegetable and fruit production in established agricultural settings. The principal research was an evaluation of basalt dust to increase soil fertility for lettuce production.

Regimes of soil fertility for lettuce included treatments with nutrients provided by: a mixed organic fertilizer; food-waste compost applied at 20 tons/A; and the compost with basalt dust (400-mesh) applied at 4 tons/A.

Compared with the organic treatment or with compost alone, remineralization with basalt dust elevated the concentrations of available P, K, Ca, and Mg in soil at planting and at harvest. The availability of nutrients rose between planting and harvest in remineralized soils, whereas nutrient levels fell with the other regimes. Benefits of rock dust in maintaining or enhancing levels of soil nitrate and organic matter were apparent. The results support remineralization as a means of sustaining soil fertility by elevating levels of available plant nutrients.

Iron bioavailability of minerally versus organically fertilized crops. *Virginia Worthington,[1] Pat Millner,[2] Jeff Buyer,[2] Terry Schettini[3] and Laurie Drinkwater.[3]*

[1]School of Public Health, Johns Hopkins University, Baltimore, MD; [2]Soil Microbial Systems Laboratory, U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville, MD 20705; [3]Rodale Institute Research Center, 611 Siegfriedale Road, Kutztown, PA 19530.

Alternative cropping methods show increased Fe content of crops, but it is unclear whether the increased Fe is available for intestinal absorption in humans. Certain transition metals, such as Cu, Zn, and Mn, compete with Fe for absorption, while ascorbate enhances Fe absorption. This study measured bioavailable Fe and nutrients that can affect bioavailability in spinach and green peppers produced with three organic fertilizers (dairy cow manure, broiler manure, and compost) and conventional fertilizer.

For spinach, total Fe was higher in the compost treatment, but not significantly. Soluble Fe was significantly higher ($p<06$) in spinach fertilized with conventional mineral N fertilizer. The fraction of soluble Fe that was bioavailable was significantly greater for the compost and manure treatments than for the mineral fertilizer treatment in both spinach ($p<06$) and green pepper ($p<0001$). The greater fraction of bioavailable Fe in crops fertilized with compost or manure may be due to greater ascorbate content, which keeps Fe in the ferrous form, and to lower levels of minerals that compete for intraluminal binding sites.

In contrast to previous reports, fertilization method did not significantly influence ascorbate content in spinach, possibly because in this study spinach was grown as a spring crop and was not fully mature at harvest, although it was of marketable size. Both immaturity and spring cropping tend to produce lower ascorbate content in spinach.

Ascorbate in green pepper, on the other hand, was significantly greater ($p<03$) with compost. This may partially explain the higher Fe biovailability in peppers from the compost plots. Excess N in the plant favors protein formation over carbohydrate synthesis. Since ascorbate is formed from available glucose, any reduction in carbohydrate synthesis reduces ascorbate production. Raw manure and conventional fertilizer release N more rapidly than does compost, allowing plants to take up more N and hence produce less ascorbate, as seen in green peppers.

Mineral contents generally were greater in crops produced with mineral fertilizer. This trend was statistically significant for Zn in spinach ($p<10$) and for Zn and Mn in green peppers ($p<01$). N release in soil lowers soil pH, which weakens mineral-chelate bonds, thus facilitating mineral absorption by plant roots. Soil pH of 6.4 was recorded for plots treated with mineral fertilizer, versus 6.6 and 6.9 for dairy and broiler manure.

The effect of an alternative cropping system on tomato fruit quality. *Amy Oberly, John Masiunas and Mosbah Kushad. University of Illinois, 260 ERML, 1201 W. Gregory, Urbana, IL 61801.*

Cover crop residue used in alternative cropping systems will affect soil nutrients, soil moisture, and soil temperature. Each of these factors can affect tomato fruit quality. A field study was conducted comparing the effects of a rye cover crop, tomato variety, and N fertility on tomato fruit quality. Cereal rye was seeded at 100 kg/ha on half the plots in October 1995. The rye was killed in mid-May 1996. Tomato seedlings were planted into both the rye and bare ground plots on June 4, 1996. Four varieties of tomatoes were used: 'Pik Red' (susceptible to cracking); 'Mountain Supreme' (resistant to cracking); 'UC82B' (low soluble solids); and 'Cherry Express II' (high soluble solids). Two fertilizer regimes were used: no additional fertilizer, and N fertilizer broadcast after tomato planting, based on soil tests and current recommendations. The N was applied as urea at a rate of 110 kg/ha. Tomato quality was evaluated on color (assessed using a Minolta chromameter), cracking (type and severity), and soluble solids (determined by HPLC).

Accumulation of nitrate in vegetables and of phosphate in the rhizosphere by overuse of organic fertilizer. *Sang Mok Sohn. Faculty of Plant Resources, College of Agriculture, Dan Kook University, 330-714 Cheon An, Republic of Korea.*

There is still no basic standard for organic agriculture in Korea and Japan. Organic farmers in these countries do not follow the minimum standards of the International Federation of Organic Agriculture Movements (IFOAM). Most just practice organic agriculture by applying organic fertilizer and commercial seeds without legumes, rotations, or green manures. They believe this system is environmentally friendly and that it produces safe products, because they are not at all aware of the basic standards of organic agriculture.

Some organic farmers have caused severe problems in Korean organic agriculture because they apply too much organic fertilizer compared with the needs of the crops. An investigation showed high nitrate accumulation in vegetables grown with organic farming: 1,000–6,000 ppm in chinese cabbage and 1,500–9,000 ppm in kale in Korea, and 2,500–5,000 ppm in the root and 2,500–9,000 ppm in the leaf of kabu in Japan. However, with chinese cabbage, lettuce and radish, nitrate content does not go higher than about 1,500 to 2,000 ppm if organic fertilizer is applied at no higher than the need of the crop. Accumulation of P_2O_5 in the rhizosphere (0–30 cm and 30–60 cm) of these crops was 400–950 ppm. These accumulations of nitrate and phosphorus show the potential risk of nitrate leaching and phosphate runoff under Korean cropping systems and climatic and soil conditions.

It is recommended that organic farmers apply organic fertilizer at an appropriate rate determined by soil testing to avoid nitrate accumulation in the edible parts of vegetables and in the rhizosphere. It also is necessary to introduce the basic IFOAM standards into Korea and Japan immediately.

Organic Farming and Food Quality

***Long-term field experiment in Sweden: Effects of organic and inorganic fertilizers on soil fertility and crop quality.** *Artur Granstedt,[1] Lars Kjellenberg[2] and Pirko Roinila.[1]*

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In 1958 Bo Pettersson at the Nordic Research Circle for Biodynamic Agriculture in Järna, Sweden, began an agricultural field experiment that lasted until 1990 (32 years). The experiment included eight different fertilizer treatments, each with a four-crop rotation, without replication: spring wheat, clover/grass mixture, potatoes, and beets. The primary focus was aspects of crop quality, and the fertilizer application rates for the various treatments were adjusted to bring about comparable yields.

Between 1958 and 1990 yields in all treatments increased, consistent with the trend in Swedish agriculture, but the increase was greatest in the organic treatments (65% in the biodynamic compared with 50% in the conventional). The spring wheat and beet yields increased with fertilization, and there also was a considerable yield difference between plots receiving compost with biodynamic sprays and those receiving just compost. The effects of the different fertilizer treatments on product quality and soil fertility are in accordance with findings in later studies developed on the basis of this original investigation, which were conducted in Uppsala (1971–1976) and Järna (1971–1979). Compared with the conventional treatments, in potatoes and wheat the content of crude protein in the organic treatments was lower but protein quality was higher (i.e., relatively pure protein and essential amino acids, lower amounts of free amino acids). In potatoes, storage quality and resistance against deterioration was higher in the organic treatments, and in wheat the starch quality seemed to be higher in the organic treatments. This has been described as a higher level of organization that is evident in both soil and crop formation as a result of the long-term effects of organic manure compared with conventional NPK fertilizer.

New experiments in Sweden and Finland have been started to study the effects of different organic treatments on farms. Preliminary results of these experiments confirm

the differences described between organic and inorganic treatments, but also show that the effects of liquid organic manure on quality parameters are closer to those of inorganic fertilizer.

***Yield, product quality and soil life after long-term organic or mineral fertilization.** *Joachim Raupp. Institut für Biologisch-dynamische Forschung, Brandschneise 5, D-64295 Darmstadt, Germany.*

An experiment was started in 1980 comparing the following types of fertilization: composted cattle manure and urine, with and without all biodynamic preparations, and mineral fertilizer. Each type is applied at three different rates to four crops each year.

The humus content of the soil at the beginning of the trial (1.05% C) was maintained only with manure fertilization with biodynamic preparations; the other treatments showed a clear decline. Microbial biomass and soil enzyme activity were higher with manure than with mineral fertilizer. Some soil biological parameters have been further increased by the biodynamic preparations.

Yield of spring wheat, averaged over all years, was 3.5 t/ha for both manure and mineral fertilization. Potato and winter rye yields were higher in most years with mineral fertilization than with manure (27.3 compared with 24.6 t/ha for potato, and 3.6 compared with 2.7 t/ha for winter rye). Application of biodynamic preparations increased potato yields in most years, by an average of 1.6 t/ha.

From data on yield of spring wheat for eight years, favorable growing conditions (weather) seem more important with mineral than manure fertilization for achieving high yields. Under poor growing conditions (dry years), yields with mineral treatments declined more than with the manure treatments, for which yields were more reliable.

Carrots, beets, and potatoes were much lower in nitrate with manure than with mineral fertilization. Under optimal storage conditions only small differences were found; clearer effects, mostly in favor of manure fertilization, occurred under stress conditions.

Comparison of selected vitamins in organic vs. conventionally grown carrots and broccoli as purchased. *Joseph Maga, Karen Wilken and Chia-Hiang Shao. Dept. of Food Science and Human Nutrition, Colorado State University, Fort Collins, CO 80523-1571.*

Consumers who choose organically grown over conventional produce do so for a variety of reasons, including a belief that organic products are nutritionally superior. Organic producers strive to promote the nutritional superiority of their products. Yet sound data remain sparse. This study compares organic and conventional fresh vegetables, as purchased, with regard to β-carotene (carrots) and vitamin C (broccoli). Samples of produce marketed as organic or conventional were collected from two grocery stores in Fort Collins, Colorado over a five-month period and analyzed. No clear trends were observed. Variations from varietal differences, growing location and conditions, storage, and transportation were masked by the collection protocol and sample sizes.

Comparison of selected nutrients in organically grown spinach, broccoli varietals, and winter squash as influenced by storage. *Joseph Maga, Karen Wilken and Lewis Grant. Dept. of Food Science and Human Nutrition, Colorado State University, Fort Collins, CO 80523-1571.*

Savory spinach was analyzed for nine minerals and seven vitamins 12 hours after harvest. These data were compared with the same product stored at 8°C for five days. The most noted change was a 10% drop in vitamin C with storage. All other nutrients were not significantly different. Four different broccoli varietals were analyzed immediately after harvest, and after five and nine days of storage at 8°C. Vitamin C decreased significantly with storage, with only minor changes noted in the other nutrients. Varietal differences were not observed. Similar trends were noted for winter squash stored for up to three months under commercial conditions.

Comparison of selected nutrients in organic vs. conventionally grown potatoes under controlled growing conditions. *Joseph Maga and Karen Wilken. Dept. of Food Science and Human Nutrition, Colorado State University, Fort Collins, CO 80523-1571.*

The same potato variety, 'Sangre,' was grown on the same soil type under four diverse conditions within a five-mile radius. The conditions included: intensive production (200-150-80 fertilization with insecticide and fungicide); conventional (120-150-80 fertilization with insecticide but no fungicide); traditional organic (hog manure and rotation with fallow on land used for organic production for 10 years); and virgin organic (cow manure on land cleared of brush). A total of nine minerals and seven vitamins were analyzed within one month of harvest in potatoes that were stored under commercial conditions. Accounting for variation among tubers, there was a 10–12% difference in nutrients, with no clear trends associated with production techniques.

***Farming practices and food quality in Lithuania.** *Vida Rutkoviene, Antanas Stancevicius and Grazina Rutkauskiene. Applied Ecology Department, Lithuanian Academy of Agriculture, 4324 Kaunas.*

Two field experiments were carried out at the Experimental Station of the Lithuanian University of Agriculture. Experiment 1 compared three farming systems (organic, integrated, and conventional) for field crops on two soil horizons, one normal, one deepened by adding a layer of humus. The experiment studied a four-year crop rotation, in three replicates, from 1991 to 1996.

Experiment 2 evaluated the influence of different kinds of fertilizers (organic and mineral) on the quality of carrots, potatoes and cabbages. The experiment was carried out for three years, in three replicates. Yields and the chemical composition of the soil and plants have been measured.

Yields of field crops and vegetables were lower with organic practices than with mineral fertilizers. The difference depended strongly on crop (very significant for barley, less so for winter wheat and vegetables). Energy use in the organic system was 40% lower and in the integrated farming was 30% lower than in the conventional system. Traditional chemical analyses of nutritional value did not show strong, consistent effects of different farming practices on product quality. An index of vitamin/nitrate is proposed as a parameter for evaluation of food quality.

***Quality comparison of mineral, organic, and biodynamically cultivated potatoes: Contents, strength criteria, sensory investigations, and picture-creating methods.** *D.G. Schulz,[1] K. Koch,[2] K.-H. Kromer[2] and U. Köpke.[1]*

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The nutritional quality of food can be characterized by the content of beneficial and harmful substances. For today's consumers the most important criteria for buying potatoes are taste, quality, and shelf life.

Biodynamic preparations are used by about 20% of all organic farmers in Germany. These preparations do not primarily serve to increase yield, but are said to support the production of high quality food having balanced nutrient content and improved shelf life characteristics. Since 1993, investigations have been conducted to evaluate how some of these parameters are affected by mineral fertilization and organic manuring at different rates, combined with application of biodynamic preparations.

Potatoes (variety 'Granola') responded only slightly to the factors of the trial, so that statistical differences could be confirmed only in a few cases. Tubers from the plots receiving mineral fertilizer showed the strongest response to elevated fertilization (decreases in dry matter, sucrose, chloride, and density, and increases in glucose, fructose, fluoride, and ash). Only in three parameters did tubers from the biodynamic plots respond to higher fertilization the same as the organic ones (increases in chloride and ash, constant fluoride). In four parameters, the biodynamic tubers showed at most a weak response, whereas organic potatoes showed decreasing dry matter and sucrose contents but no distinctive tendency in glucose or fructose. Strength was assessed as lowest in potatoes receiving mineral fertilizer. The sensory investigations did not differentiate among the three systems, but there is a tendency for sensory quality to deteriorate with increased fertilization, particularly for the tubers from the mineral plots. The results of the determination of vital quality using picture-creating methods confirmed that this assay is applicable to additional quality determinations.

A final assessment of quality for the different cropping systems cannot yet be made. Therefore, additional parameters will be analyzed (nitrate, potassium, amino acids, and ascorbic acid), which may allow a final assessment in combination with the present data. Also, the current trials might reveal whether other varieties respond more strongly to the relevant factors.

Nutritional evaluation of carrots cultivated in conventional and ecological farming systems: A paired-farm comparison. *Hanne Torjusen,[1] Helle Margrete Meltzer[1] and Geir Lieblein[2]*

[1]Nordic School of Nutrition, University of Oslo, PO Box 1046, Blindern, N-0316 Oslo, Norway; [2]Dept. of Horticulture and Crop Sciences, Agricultural University of Norway, PO Box 5022, N-1342 Ås.

Currently, ecological farming (equivalent to U.S. "organic farming") is practiced on approximately 960 farms in Norway, representing about 1% of the total farmland. There has been a great increase of interest in ecological farming and ecologically grown produce, and it is a common view among consumers that in addition to the environmental benefits, ecologically grown produce is "healthier" than conventionally grown food.

The aim of this study has been to contribute to the clarification of how ecological and conventional produce might differ in nutritional quality. Carrots cultivated in conventional and ecological farming systems were compared regarding nutritionally relevant variables. The carrots were part of the regular production on 20 farms, consisting of ten pairs of neighboring conventional and ecological farms in southern Norway. The following variables were analyzed: nutrient content (minerals, trace elements, and carotenoids); potentially harmful substances (Cd, Pb, Al, and NO_3^-); "non-nutrients" (polyphenolic compounds); and sensory quality.

For most variables, there were no statistically significant differences between the two groups of carrots. However, there was more β-carotene, total carotenoids, Mn, and Mg in the conventionally grown, and more Al in the ecologically grown carrots. On seven of the ten pairs of farms the same variety of carrots was grown within each pair. Within this subgroup, there were statistically significant differences only for carotenoids. Differences in crop varieties might therefore have influenced the results.

The sensory evaluation, in which carrots from eight farms (four pairs) were ranked by a taste panel, did not show a difference between ecological and conventional methods. The carrots from one conventional farm were clearly preferred, while carrots from two other conventional farms were ranked lowest. The ecologically grown carrots were evaluated to be similar in taste.

In the Cand.scient. thesis on which this paper is based, the results are discussed from the viewpoint that conventional and ecological farming systems belong to two separate paradigms. An expanded quality perspective is applied and different views of what should be considered "nutritionally relevant" are discussed.

Enhancing the Nutritional Quality of Crops

Improving the nutritional quality of foods using sustainable soil-plant-animal system approaches. *Ross M. Welch. USDA Plant, Soil and Nutrition Laboratory, Cornell University, Ithaca, NY 14853.*

Health, nutrition, food security, and national development are interrelated. Ultimately, the source of nearly all nutrients for humans are plants. Agricultural systems are responsible for producing these foods, and therefore are the paramount determinants of the supply and balance of available nutrients for people. The foundation of sustainable nutrition resides with agricultural systems that provide adequate nutrient output to meet the needs of societies. In the face of prevalent malnutrition, one must ask how agricultural systems can be changed to allow all people access to enough nutrients to meet their nutritional requirements. Agricultural systems can be designed to maximize available nutrient output, ensuring sustainable supplies of nutrients to meet people's needs. However, this requires an understanding of soil, plant, and animal systems and their interactions.

Understanding the processes that control the movement of essential nutrients through the human food chain begins with an understanding of the soil processes that

affect mineral nutrient availability to plants. Soils are the primary source of all mineral nutrients that enter the soil-plant-animal-human food chain. They are the nutrient medium for plant growth, and as such affect the accumulation of nonmineral nutrients produced by plants, such as essential vitamins, amino acids, and fatty acids. Improving the nutritional quality of plant foods must begin with improving the availability of soil mineral nutrients to food crops. Discerning the processes controlling nutrient accumulation in edible plant products is needed to ascertain ways of increasing the available nutrient content of food crops. Food crops are the preeminent source of nutrients for humans. Also, the forms of nutrients accumulated by food crops and the presence of "antinutrient" or nutrient "promoter" substances must be known to ensure that the nutrients accumulated by food crops are available to the humans consuming them.

Understanding the dietary interactions between nutritionally important substances in animal or plant food products and nutrient availability to humans is essential in developing food systems that provide adequate and balanced nutrient supplies. Animal products are a rich source of some nutrients, including certain essential amino acids, fatty acids, lipids, minerals such as calcium, and micronutrients such as iron, zinc, and vitamin B_{12}. Thus, sustainable agricultural systems must have an efficient combination of both animal and plant food enterprises to ensure adequate nutrition for all.

Possible approaches to increasing production and availability of vitamin A-containing foods. *Clive E. West[1] and Leda E. Nemer.[2]*

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This study examines the factors that play a role in decreased agricultural production and that influence vitamin A availability in foods in sub-Saharan Africa, using revised retinol equivalencies based on the food matrices. In this context, the agricultural system is examined regarding production, human and economic factors, food storage and processing procedures, and its effect on intake of vitamin A-rich foods, absorption, vitamin A status, and health.

The ability of various foods to meet vitamin A requirements is examined, based not only on their provitamin A carotenoid and retinol contents, but also on bioavailability. One factor determining bioavailability is the food matrix. It is generally not a limiting factor in retinol-containing foods. However, chloroplasts in dark green leafy vegetables and crystals in carrots markedly reduce the bioavailability of carotenoids compared with chromoplasts in yellow and orange fruits and vegetables, which have less of an effect.

Strategies aimed at achieving a permanent increase in the intake of locally acceptable foods containing bioavailable vitamin A also are examined. These include agricultural factors such as seasonality, improvement of present cropping patterns, adoption of vitamin A-rich foods, and government interventions that contribute to an increase in the quality and production of vitamin A-containing foods.

***Exploring the potential to enhance dietary iron from a green leafy vegetable.** *Anusuya Rangarajan. Dept. of Fruit and Vegetable Science, Cornell University, 134-A Plant Science Bldg., Ithaca, NY 14853.*

Iron deficiency is the most prevalent mineral nutrient deficiency affecting humans worldwide. Green leafy vegetables (GLVs) could provide an excellent source of iron to the diet if the bioavailability of this iron is improved. Previous studies of the iron nutritional quality of GLVs have been conducted primarily by using a "market basket" approach in which GLVs are collected from local markets and analyzed for iron content. Although this method does provide some information on the amount of iron people may consume, it provides no indication of the differences in iron bioavailability due to plant genetic variation, cultural practices, or postharvest handling methods.

The following research investigated the potential for use of plant breeding and cultural practices to enhance the amount of bioavailable iron in a GLV. To explore the genetic variation in this trait, 46 lines from 12 species of amaranth (*Amaranth* spp.), a popular tropical GLV, were screened in greenhouse and field studies. The bioavailable iron was estimated using an in vitro assay simulating gastrointestinal digestion, and the results were confirmed using an animal bioassay.

Significant differences in the fraction of total iron measured as bioavailable were detected among species of amaranth, with a range of 6 to 12% in field-grown plants. Although total iron concentrations of leaves did not correlate with bioavailable iron, species that accumulated higher total iron tended to provide more bioavailable iron to the diet. Large fluctuations in the total iron concentration of leaves, which were observed at different harvest times and in two production environments, did not lead to similar changes in bioavailable iron. The genetic variation in iron bioavailability was confirmed using a hemoglobin regeneration assay in anemic rats, supporting the use of the in vitro assay in breeding programs focused on improving the iron nutritional quality of GLVs.

***Integrated pest management in non-rice food crops in Indonesia: Opportunities to reduce chemical pesticide use**. *Michael Hammig,[1] Aunu Rauf[2] and Gerald Carner.[3]*

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We report on an ongoing research and extension effort to introduce economically and biologically effective systems of insect pest control in non-rice food crops in Indonesia that reduce reliance on chemical pesticides. Research at the farm level is underway to develop IPM systems for these important crops. The potential economic and environmental payoff is very high. While the average number of chemical sprays per season in non-IPM rice is about seven, in vegetables it is much higher—up to 20–25 on shallots and cabbage. As a result of Indonesia's rapidly growing economy, consumption of high-valued vegetables is rising. Contamination from pesticide residues is a serious problem for consumers. The impact of excessive sprays on vegetable producers using inadequate protection is severe. Water systems that provide irrigation to fields and that also

supply homes are contaminated by chemical runoff.

IPM alternatives in two of the most important vegetables crops—shallots and cabbage—promise to break this dependence on chemical controls. The system for shallots replaces chemical pesticides with a naturally occurring virus found on the same host pest, *Spodoptera exigua*, in other parts of Indonesia. It is used in combination with routine hand picking of insect egg masses. The system for cabbage relies on introduction of a wasp parasite, *Diadegma semiclausum*, to control the early-season pest *Plutella xylostella*, followed by hand picking of larvae and egg masses and occasional spot spraying of the biological insecticide *Bacillus thuringiensis* to control the late season pest *Crocidolomia binotalis*. The aggregate economic impact of these systems is in the range of $80 million per year just in reduced production costs. Impacts on health and nutrition are less easily estimated, but they are large enough to justify an aggressive policy to expand the use of IPM in vegetables in Indonesia and other countries with similar cropping systems.

Are colored bell peppers as high in vitamin C as the green ones? *A.H. Simonne,[1] E.H. Simonne[1] and R.R. Eitenmiller.[2]*

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Most fruits of common bell pepper (*Capsicum annuum* L.) are green at the unripe stage and become red as they ripen. Currently USDA Handbook 8-11 only lists vitamin C levels for green and red peppers (128 mg/100 g). Over a two-year period, we evaluated nineteen cultivars, including green, yellow, red, orange, brown, white, purple, and black. Also, the magnitude of change in vitamin C content was evaluated by using four growing locations representative of the southeastern United States. Soil types were fine to coarse sandy loams. Cultural practices included bare ground and black or white plastic mulch with overhead or drip irrigation. Vitamin C was determined by the AOAC microfluorometric method.

Overall means (ranges of means by location in parentheses) of vitamin C levels (mg/100 g) were as follows, with means followed by a different letter significantly different ($p<05$) according to Duncan's multiple range test: yellow, 143a (124–211); red, 143a (124–164); orange, 141a (120–163); brown, 136a (117–154); white, 108ab (102–117); green, 98bc (84–118); purple, 93bc (67–112); and black, 65c (61–67). The highest variation in vitamin C was observed in cultivars that had the highest vitamin C levels. Yellow, red, orange, and brown peppers had higher vitamin C content than the values given in USDA Handbook 8–11; green, purple, white, and black peppers had lower levels. All pepper cultivars provide at least 100% of RDA per 100 g serving.

The role of food processing for improving the nutritive value and cooking quality of legume seeds. *M.M. Tabekha. Faculty of Agriculture, Dept. of Food Science and Nutrition, Mansoura University, PO Box 35516, El-Mansoura, Egypt.*

The success of agricultural science since World War II has led to the availability of cheap, abundant food from field crops, fruits, and vegetables. Legume seeds are second only to cereals as a source of human and animal food. Nutritionally, they are two to three times richer in protein than cereal grains.

Malnutrition usually is prevalent where only a few different plant foods are available. Animal protein seldom is affordable for the diets of the poor in developing countries, so legumes usually provide the chief and sometimes the only source of protein. Legumes contain a greater variety of toxic constituents than do any other plant family. Some legume seeds are highly toxic, containing flavonoids, alkaloids, nonprotein amino acids, tannins, phytates, or oxalates. Dry beans also may contain compounds that cause flatulence and agglutinate certain blood types. Dry legume seeds are difficult to cook, and the large amount of fuel needed to cook them tends to discourage their use by people in rural areas where fuels such as firewood are diminishing.

Processing legumes by soaking them in water and sodium carbonate before cooking reduces the cooking time considerably and improves their quality. Many of the toxins can be neutralized in simple ways: for example, phytate and tannins by soaking the seeds in water or by cooking them thoroughly. Canning and sprouting the seeds improve their nutritive value. All these processes produce wholesome, edible products free of toxic substances. Processing of legume seeds also eliminates inhibitors of the enzymes that digest protein, and may improve the absorption of amino acids from the digestive tract.

Food processing thus improves the food value of legume seeds. Appropriate technology in combination with modern food technology can help in producing abundant, safe, and nutritious legume seeds.

Animal Production

***Broadening the concept of quality for animal products: A German perspective.** *Engelhard Boehncke. Division of Organic Animal Husbandry, University of Kassel, Nordbahnhofstraße 1a, D-37213 Witzenhausen, Germany.*

The generally accepted criteria for meat, milk, and egg quality, such as hygienic safety, freshness, and nutritional value, no longer are sufficient for the more subtle among German consumers. Additional criteria involving subjective values are necessary to ensure that these consumers get the quality they want.

One of the most relevant aspects is regional production. This concept clearly has arisen with BSE, so that its current importance may be transitory. However, it accords well with the political concept of regional rural development.

The ethical value of animal products is related mainly to housing systems, transportation to the slaughterhouse, and slaughtering methods. Today this concept is based on several ideas: the dignity of living creatures, the prohibition against letting animals suffer, and the competition between animals and man for food in the context of global hunger problems.

Ecological food quality is closely connected to animal and human health, but also to ethical aspects. High ecological quality means that food of animal origin is produced with as little environmental damage as possible.

At present there is a heated debate concerning the threat from the use of antibiotic growth promoters for fattening

farm animals. These compounds lead to growing resistance of pathogenic bacteria and, therefore, to serious and well-documented problems in human medicine. Not using antibiotic growth promoters consequently increases the ecological, hygienic, and ethical value of animal foods.

***A systems analysis of BSE: Lessons to be learned.** *Sean Beer. Centre for Land Based Studies, Bournemouth University, The Lindens, East Lulworth, Wareham, Dorset BH20 5QT, UK.*

Currently, Great Britain and Europe are gripped by a crisis in food production and consumer confidence. The incidence of Bovine Spongiform Encephalopathy (BSE) in European cattle, predominantly those of Great Britain, and the perception that this disease might be transferable to humans, have resulted in a collapse of the European beef market.

One characteristic of the crisis has been the confused nature of scientific and political maneuvering with regard to the issue. There is a perception that vested interests and expediency have lead to a less than full analysis of the nature of the disease, its possible causes, methods of control, and implications for the future of food production. Certainly, no one person seems to have produced a clear, basic analysis of the current situation.

This paper endeavors to perform a systems analysis of BSE. The basis for this is a review of the available literature, consultation with various involved bodies, and my direct involvement in the UK beef industry and in attempts to manage the situation. A model is proposed that examines BSE from a systems perspective. A range of possible contributory factors are illustrated, along with potential methods of control and the implications of existing policy. From this, key factors are identified that could be of great importance for various food production/consumption systems around the world.

Grass feeding impact on cholesterol and fat levels in beef cattle. *Andras Gil, Stella Huertas and V. Urrestarazu. Facultad de Veterinaria, Catedra de Bioestadística, CP 11.600, Lasplaces 1550, Uruguay.*

Fat and cholesterol levels in meat, and their relation to blood cholesterol, have become important issues worldwide. The hypothesis is that cattle diets are related to fatty acids and cholesterol levels in meat, so that it is possible to produce more healthful meat with proper feeding.

We selected 34 pairs of Hereford steers from different farms, matched by farm, age, breed and weight. One member of each pair was randomly allocated to grass, the other to a grain-based diet formulated according to NRC tables: corn, 87%; soy flour, 10%; urea, 0.4%; and salt, 0.5%; also, they had hay *ad libitum*.

Steers were slaughtered at an average weight of 440 kg. Meat samples were collected from *L. dorsi* (strip loin) and Semitendinosus muscle (eye round). The Folch extraction method and chromatography were used to determine fat levels and cholesterol. Data were analyzed for a matched design using PC SAS.

As expected, the grain-fed group grew more quickly, and so were finished first. They had higher fat deposition than did grass-fed steers of similar weight. The increase in fat in grain-fed steers was: cavity fat, 25%; covering fat, 50%; intramuscular fat (marbling), 49–70% from eye round to strip loin. The cholesterol level in the grain-fed animals was 13% higher than in the grass-fed group. Percentage of saturated fatty acid as stearic acid (18:0) was higher in the grass-fed animals, but there was no increase in serum cholesterol level. Fat content was the only difference between the two groups, so that grass feeding seems the best option for healthful and economic meat production in Uruguay.

Designing broiler feeding regimes for the production of nutritionally enhanced breast meat. *M.E. Van Elswyk[1,2] and J.W. Mooney.[2]*

[1]Faculty of Nutrition and [2]Dept. of Poultry Science, Texas A&M University, College Station, TX 77843.

The US Dietary Guidelines recommend fish as a low-fat source of protein and n-3 fatty acids (n-3 FA). Dietary n-3 FA are believed useful for reducing heart disease risk. Unfortunately, a disparity exists between nutritional recommendations and dietary practice, as consuming 200 g of fish per week is considered healthful but consumption of only 89 g per week is reported by the U.S. Department of Agriculture. Manipulation of poultry feeding regimes to include a source of n-3 FA results in a poultry meat rich in these essential nutrients. Commercial realization of this feeding practice, however, depends on coordinating dietary enrichment in a manner that will yield maximum n-3 FA deposition with minimal increases in production costs.

The current study investigated the combined use of a drum dried, docosahexanoic acid (DHA)-rich marine algal product (MA) (DHA-Gold™) and whole flaxseed (F) during a staggered feeding regime. Broilers (n=100 per treatment) were fed typical diets or diets containing 2.75% MA and 2.5% F beginning either 28 days or 20 days prior to slaughter, or 5.5% MA and 5.0% F beginning 10 days prior to slaughter. At slaughter (49 days of age), the *pectoralis major* was selected to determine breast meat fatty acid content (n=30 per treatment).

Breast muscle from birds fed the 10-day diet exhibited significantly ($p<05$) higher total fat. This increased fat deposition was predominately as saturated (SFA) and mono-unsaturated (MUFA) fatty acids. The SFA and MUFA content of broiler breast meat from the 28-day and 20-day diets was not significantly different from the controls. Regardless of the enrichment period, n-3 FA-rich rations yielded 130 to 150 mg of n-3 FA per 100 g of breast meat, predominantly as DHA (22:6n-3). Linolenic acid (18:3n-3) from whole F was minimally deposited. These data suggest that feeding n-3 FA to broilers 20 days prior to slaughter produces a breast fillet that could substitute for a serving of lean fish in the diet with minimal increase in production cost.

Achieving improved nutritional quality through changed meat production technologies. *Helen H. Jensen. Dept. of Economics/CARD, Iowa State University, Ames, IA 50011-1070.*

In the US diet, approximately 37% of food energy is derived from total fat. Recent evidence links consumption of fat and of fat rich in saturated fatty acids to adverse health consequences. This has prompted leading health organizations to recommend reducing the consumption of

total and saturated fat. Approximately 56% of all dietary fat and 70% of saturated fat come from animal sources. This paper addresses the technological, economic, and public policy (including regulatory) aspects of changing the composition of animal fat through changes in animal production and feeding practices, and of achieving improved human health outcomes with the new product.

The specific example used is the technology of modifying fat composition and deposition in hogs through dietary intervention. A pork fat modification experiment currently underway at Iowa State University has produced pork with modified fatty acid composition, specifically attempting to decrease the proportion of saturated fat and decrease the proportion of palmitic acid (16:0) relative to stearic acid (18:0). The early results showed that a ration with feed supplemented with 30% of calories from soy oil achieved a product with a lower ratio of palmitic to stearic acid compared with the control. Results from processing studies, a sensory panel, and human feeding studies support the result of technically feasible improved (healthful) characteristics achieved through changes in pig feeding practices.

The paper provides a summary of the earlier results (some already presented or published) and then, using available industry and economic data (e.g., feed input prices, feed conversions, output prices, and production decision parameters), evaluates the economic consequences and feasibility of using a feeding innovation to improve pork products. Current findings indicate that a price premium of 8% would be required for adopters (50% adoption rate) to break even, and 30% for the industry as a whole. Public policy tradeoffs based on the scope of changing the healthfulness of meat products in this way versus the value of more direct health interventions are examined.

Consumer Issues

***The British food consumer: Victim or villain?** *Sean Beer. Centre for Land Based Studies, Bournemouth University, The Lindens, East Lulworth, Wareham, Dorset BH20 5QT, UK.*

The consumer, we are told, is King. There also is a popular perception that the consumer is not only aware of but also concerned about the nutritional value and safety of food. This concern is part of a growing awareness of our environment and associated "green" concerns. In Great Britain, a series of sensational food scares (salmonella, Listeria, and BSE) has rocked the public's perception of many traditional foodstuffs as safe and wholesome. One would therefore expect the consumer to be making informed purchasing decisions and to be shaping food culture.

Consumers have power and therefore responsibility. There also is a self-evident cause/need for consumers to act. One would therefore expect that the consumer would exercise this power in the marketplace and thereby influence production systems. The evidence for this actually taking place in Great Britain is limited. This could be due to a variety of factors, principally: the price/quality trade-off; poor consumer education; food marketing and the manipulation of popular food culture; and green and cultural tokenism.

This paper examines the relationship between the consumer, producer, and retailer. The analysis uses a simple cultural studies model developed previously by Dr. M. Redman and me. The basis for the research is a review of the available literature and consultation with various involved bodies. Several conclusions are drawn, particularly the need for a coherent, universal food labelling system. This is discussed along with examples of such systems.

***Marketing of organically grown agricultural products in Turkey: Current status and future prospects.** *Sedef Akgüngör,[1] Canan Abay[2] and Bülent Miran.[2]*

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The development of organic agriculture in Turkey dates back to the early 1980s with traditional crops such as dried figs, raisins, and dried apricots. Currently, 24 different species are organically grown, including fruit trees, vegetables, cereals, cash crops, and legumes, and almost all are exported.

The aim of this paper is to study the current status of organic farming in Turkey, with emphasis on marketing of organic products. Another aim is to discuss the possibilities for creating a domestic market for organically grown products in Turkey.

We discuss the structure of the market for organically produced goods and present the coordinating mechanisms in the marketing of organic foods in Turkey. Next we discuss the performance of the market for organically grown agricultural products, using raisins as a case study. Performance is evaluated by comparing supply and demand, stability of markets and prices, stability in producers' profits, and organizational flexibility in the market.

Surveys with producers and interviews with exporting firms were conducted in the Izmir region, where most exporting firms in Turkey are based. The producer surveys revealed that organic farming through contracts is an effective tool to increase the welfare of small farmers. Potential expansion of organically produced agricultural goods into domestic markets is evaluated through consumer surveys in the Izmir metropolitan area. The surveys reveal that most consumers are willing to buy organically grown products if certified organic products are available in the market.

***Consumer response to organic production: A case study of emerging trends in developing countries.** *Mahesh Chander[1] and H.C. Tewari.[2]*

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Because of the growing importance of organic production even in food-deficit developing countries, a study was conducted of organic vegetable production and marketing to test its feasibility and consumers' responses. Vegetables were grown according to organic standards on 0.5 ha of land in each of two locations, and were sold (0.5 and 0.75 t, respectively) directly to 475 consumers on-farm. Pest and disease problems could not be controlled effectively with organic methods, which reduced production. This suggests the need for effective organic control methods for sustainable production.

Consumers were surveyed through a questionnaire about their opinions of the organic concept. Consumers at the first location, who were aware, educated, and employed, showed a highly enthusiastic response for reasons of taste, freshness, and health benefits. Some even were ready to pay premium prices, but a few emphasized studies on sustainability and food security against the growing demand for ever-increasing food production.

The situation was different at the second location, where consumers were not an aware, educated, high-income elite. To them, the price of the products was the only criterion, though some acknowledged the taste and nutritional value of organic products. Further research involving a larger study is examining whether consumers were drawn to organic vegetables by a purely psychological response or by the taste, freshness and health benefits. However, chemical-intensive production certainly has generated fear, at least among the aware population in developing countries; accordingly, the domestic demand for organic foods is rising.

The lack of reliable data on production, export and domestic market potential and affordable certification mechanisms, plus poor policy support and the lack of sustainable production methods, are some obstacles for organic production in developing countries, though a significant area is under natural farming but is targeted for Green Revolution technology-based development. However, the market for organic products is bound to grow with growing awareness, incomes, and health and environmental consciousness. Latin American countries already have taken the lead in organic production and exports. With the sincere efforts of NGOs and good support from national governments, other developing countries may follow, as the available literature and trends indicate. This study is one among several such developments taking place in these countries, which may be followed by other innovative approaches for the development of organic farming. However, organic agriculture as an alternative sustainable food production system needs to be standardized through research, development, extension, marketing, and policy initiatives.

Consumer perceptions of locally grown IPM produce: CORE Values Northeast Apple Project. *Molly D. Anderson. School of Nutrition Science and Policy, Tufts University, Medford, MA 02155.*

The Northeast is the second largest apple producing region in the United States; yet without aggressive new marketing strategies, the present configuration of farm families and orchards is unlikely to be maintained beyond the present generation. The goal of the CORE Values Northeast research and education project is to improve the viability of the Northeastern apple industry by implementing and evaluating a public education campaign that will increase consumer preference for local apples grown with integrated pest management (IPM) and labeled at point of purchase with a regional brand.

Despite federal support for IPM research and extension and a mandate to convert 75% of US cropland to IPM by the year 2000, few studies have assessed consumer response to IPM or IPM labeling. This project is significant because linking the environmental advantages of IPM with arguments for buying local produce is likely to mobilize consumer support for local agriculture using IPM, given previously documented support for "ecologically grown" produce. Increased consumer demand for IPM-grown produce, combined with labeling to allow preferential purchase, is likely to result in higher market share for local IPM-grown apples and greater interest in adoption of standardized IPM methods by orchardists.

During the one-year pilot study reported here, attitudes about Northeastern agriculture, locally grown produce, and production methods were compared among consumers in six stores belonging to three supermarket chains in New York City and greater Boston. Comparisons were made between customers exposed to a standard "progressive marketing" strategy—brochures, posters, in-store circulars, and shelf or bin labels —and this strategy supplemented by in-store interactive demonstrations with staff members from the CORE Values Project. Results are based on a combination of qualitative data from focus groups before and after the interventions, and quantitative data from in-store surveys conducted at the six retail stores participating in the evaluation.

Consumer attitudes toward organic fresh produce: A comparison of surveys from 1991 and 1995. *Ed Sparling,[1] Karen Wilken[2] and John McKenzie.[3]*

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In 1991 we sent questionnaires to 1500 families in northern Colorado to determine consumers' attitudes about and willingness to pay for organic fresh produce. This paper compares results from our 1013 returns to results from a similar survey done for *The Packer* magazine in 1995. That study had about the same number of respondents and asked questions similar to ours, but the sample was drawn from the entire United States.

Several conclusions can be drawn from this comparison. The fraction buying organic products in the western United States in 1995 was estimated to be 58%, compared with our estimate of 45% for urban Colorado in 1991. This is not enough growth to account for the more than doubling of sales in the same period. It, therefore, is likely that growth in the market is concentrated in certain populations. Another important trend is in the reasons given for buying organics in 1995 compared with the reasons given in 1991. There is a robust conclusion that in 1995 consumers were more likely to mention quality, appearance, or freshness than concerns about pesticides or "family's health," whereas the reverse was true in 1991.

***Consumer demand for organically grown food products in urban China: Evidence from survey data.** *Qingbin Wang,[1] Catherine Halbrendt[1] and Shwu-Eng H. Webb.[2]*

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We discuss the rapid growth in China's organically grown food products, from 0.35

million metric tons in 1990 to 5.0 mmt in 1995, and present the major findings from a consumer survey conducted in Guangzhou in January 1996. The survey was designed to collect information on Chinese urban consumers' attitudes toward and preference for both organic and imported food products. The survey was completed by 500 households.

The major findings of the survey include the following: 1) about 67% of the respondents have heard about organic food products and 27% have purchased some; 2) 82% are willing to pay a premium for organic products of between 5% and 60% because of health and safety concerns; 3) 75% believe that many organic products in the marketplace are not truly organically grown and that the certification and inspection system should be improved; 4) nutrition and safety are important factors in Chinese urban consumers' food purchasing decisions; and 5) there is a strong preference for imported food products, but a majority of respondents believe that many imported products in the marketplace are not truly imported.

The rapid growth in organic foods in China in recent years is due mainly to increased consumer concerns about food safety and to the government's promotion of environmentally friendly farming methods. These two factors will continue to contribute to the growth in China's organic foods.

With its 1.2 billion consumers and its gradual transition toward a market economy, China is playing an increasing role in the world food market. We also present some findings regarding Chinese urban consumers' attitudes toward and preferences for imported food products and discuss the implications for trade.

Meeting the dietary trends of Kentuckians through agriculture. *Sandra Bastin. Food and Nutrition Extension, University of Kentucky, 235 Scovell Hall, Lexington, KY 40546-0064.*

Agriculture and human nutrition are important issues with global impacts on economic profitability, environmental stewardship, and the healthfulness of individuals. Any food resource has to be produced, processed, marketed, and utilized for maximum economic benefits and nutrient retention. Traditionally, marketing has been the individual farmer selling to wholesale or retail markets with little concern for the nutritional content of the product. However, in the last few years marketing has evolved to include farmers' markets, roadside markets, commodity groups, festivals that pair the chef and farmer in restaurant settings, and projects such as Kentucky Leadership for Agricultural and Environmental Sustainability. These activities have built confidence about the future of agriculture and the ability of people within the agricultural community to work together.

The greatest marketing tool—supporting the health of the individual—has yet to be tapped. By emphasizing safe handling of a food product, proper storage, and appropriate cooking techniques, farmers can increase awareness of products and satisfaction with meals. As a result, farmers can increase profitability through less waste and future purchases. The Kentucky Cooperative Extension Service, in collaboration with state commodity groups, developed a consumer information brochure to educate the consumer about both agricultural products available in the state and how to maximize their nutrient levels. This was first presented during the Kentucky State Fair's "Cooking with Kentucky Commodities Cooking School." The shared project will continue in local Kentucky communities with Cooperative Extension agents providing similar presentations to consumers and school-age children.

Community Supported Agriculture: Dietary Implications

***Community Supported Agriculture: A study of shareholders' dietary patterns and food practices.** *Nancy L. Cohen,[1] Jack P. Cooley,[2] Robert B. Hall[3] and Anne M. Stoddard[4].*

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Community Supported Agriculture (CSA) is a form of alternative agriculture in which consumers join a farm, pay a membership fee, and receive organically grown produce throughout the growing season. The purpose of our research was to explore the demographic profile, food patterns, and food group and nutrient intakes of CSA farm members compared with other local residents. We sent Food and Agriculture Surveys to 275 CSA members of four farms in the greater Amherst (Massachusetts) area and to 275 local nonmembers, matched by street. The survey requested information on sources of food, dietary patterns, and food intake, using a food frequency questionnaire.

Overall, a high predominance of CSA members were vegetarians, whites, people with higher incomes, and highly educated. CSA members consumed more vegetables, dark green and yellow fruits and vegetables, fiber, and vitamin A than did nonmembers. These dietary results are consistent with a majority having reported that they have increased their consumption of vegetables since joining the farm. Adjusting for vegetarianism or gardening practices resulted in similar findings. CSA membership is associated with increased nutrient intakes while providing a sustainable system of food acquisition.

Objectives and structure of a community-supported farm in the mid-Hudson River Valley and its effects on diet. *Richard S. Feldman. Dept. of Environmental Sciences, Marist College, Poughkeepsie, NY 12601-1387.*

Phillies Bridge Farm in Ulster County, New York, is both a community-supported farm and an evolving model of a form of sustainable agriculture. The Phillies Bridge Farm Project was established to create a demonstration farm with four goals: to allow young farmers to gain additional experience and practice their skills; to train aspiring farmers; to educate children about where food comes from; and to educate the adult public about how small-scale organic farming in the region enhances the economy, environment, social structure, and human health.

The practical structure for establishing this new farm was Community Supported Agriculture (CSA). This provided money up

front from interested individuals (shareholders) to pay a farmer, as well as a work commitment from each of them to assist the farmer in nearly all aspects of farm operation. Administrative and financial support also was provided by Mohonk Consultations, a nonprofit organization with the mission of supporting conservation activities.

An inactive farm has been brought back into production for two years. This past winter a survey was taken of shareholders to assess how their eating habits differed between the harvest season and winter. They also were questioned about their consumption of vegetables during the winter, as potentially influenced by their CSA experience of diverse and abundant produce. The questions address consumption of total vegetables and vegetable varieties.

Community Supported Agriculture and vegetable box schemes. *Harriet Festing. Food Industry Management Group, Wye College, University of London, Wye, Ashford, Kent TN25 5AH, UK.*

A nationwide survey of UK Community Supported Agriculture (CSA) and vegetable box schemes was undertaken in which 292 consumers and 43 producers were interviewed. The results are presented in the context of broader research findings on the nutritional implications of local marketing schemes.

CSAs and vegetable box schemes can be defined as "the regular and consistent purchase of organic fresh produce from farmers, through an advance ordering system." The 20,000 UK consumers who have joined the schemes are influenced by a complex set of motivations that combine quality, health, convenience, and environmental benefits. Members were occasional purchasers of organic foods before joining; the existence of the scheme has provided them with the impetus to consume organic foods more regularly. Case study research in the east and west of England suggests that most members are diet/health conscious and perceive organic foods to be a healthier alternative to conventional foods. Some also claim to be eating more vegetables, less meat, and more whole foods. Although generally satisfied with the schemes, UK consumers feel constrained by the lack of choice of fresh produce and poor communication channels with the growers.

Consumer profiles suggest that members of the schemes are likely to be couples between the ages of 30 and 49, in the upper income bracket, and well educated. While scheme members may feel that they have improved their diets since joining, in fact they come from the sectors of society least likely to be at nutritional risk. Their combined weekly expenditure is a tiny fraction of total fresh produce sales in the UK. Nevertheless, the CSA and vegetable box business has attracted considerable interest from the national media. The focus of such schemes on local, pesticide-free fresh produce is likely to have played an influential part in bringing about change in the sourcing and marketing of fruit and vegetables by the major supermarket chains. Press coverage, combined with increasing political goodwill, is likely to see CSAs and box schemes expand.

Agricultural production and nutrition

Lawrence Woodward

Although I admire the scientific discipline, I frequently find myself wondering whether the traditional approach to science involving testable hypotheses, replication, statistical significance and repeatability is adequate to meet the challenge of understanding such things as the complexity of whole ecological systems without taking apart and destroying the very object of the study.

There are, of course, different scientific philosophies and disciplines and different types of scientists. I suppose that some are good and some less so. According to the humorist Fran Lebowitz: "The further back one goes the science one encounters is of a consistently higher quality. For example, in studying the science of yesteryear one comes across such interesting notions as gravity, electricity and the roundness of the earth—while an examination of more recent phenomena shows a strong trend towards spray cheese, stretch denim and the moog synthesizer."

The comment is deliciously bitchy and not entirely accurate, but it does provide a route to the first observation I would like to make. Most researchers employed in the food sector in the U.K. are working on designing "novel" food products rather than on nutritional questions. I have not checked the figures but I have heard that more money is spent on development of food technology than on medical research (Cooper, 1993). This is not surprising, because it is big business.

Derek Cooper, a U.K. broadcaster on food matters, recalls addressing the executives and researchers of a company marketing Cornish Dairy Chocolate Ice Cream (Cooper, 1993). The product didn't come from Cornwall, wasn't made in a dairy, and contained neither chocolate nor cream. This wonder of modern food science was composed of "corn syrup, cheese whey, mono- and diglycerides, carob bean gum, cellulose, dextrose monohydrate, polysorbate 80, artificial flavours and colours."

This paper was the closing address at the International Conference on Agricultural Production and Nutrition, Boston, Massachusetts, March 19–21, 1997, organized by the School of Nutrition Science and Policy, Tufts University.

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Cooper suggested that the company adopt a new and upbeat marketing slogan: "Our ice cream comes from contented palm trees." He reports that the applause was exceedingly minimal.

Therefore, when it is necessary to hold a conference entitled "Agricultural Production and Nutrition," which, according to the promotional material, would "examine all aspects of the relationship between the quality/safety of food and the production systems used to raise it," should I be surprised? Probably not. Yet it does concern me that in 1997 there is still a need to organize and attend such a conference.

It seems remarkable to me that we think this issue is such a big deal that we are prepared to travel vast distances to talk about it. Isn't it notable that the issue is not regarded as commonplace? Isn't this a sign of how stupid our civilization has been? How can this be? How can such monumental folly have come about?

Of course there is a relationship between nutrition and agricultural production. *Of course* it is important, and *of course* it concerns everyone. Any half-wit ought to see that. But wisdom has been in short supply, because the relationship has not been generally recognized. Not by half-wits, full wits, ordinary wits, nor anyone else. Our civilization has been blinkered in the pursuit of quantity, probably in most of our activities but certainly in agriculture. The principles of nutrition upon which our health depends have played no part, save by accident, in our agricultural production or in the way we organize our society to grow, process, or distribute our food.

There have been warnings. There have been men and women of vision in our history who have pointed the way: Darwin, for example, and before him Plato and Aristotle. As Michael Crawford and David Marsh point out in their excellent book *The Driving Force*, to which I am indebted for much of what follows, Darwin considered that food could manipulate species and, although referring to birds, said he could "see no difficulty in parents being forced or induced to vary the food brought, and selection adapting the young ones to it, and thus by degree any amount of diversity might be arrived at" (Crawford and Marsh, 1989, p. 34). He argued that there are two factors that determine evolution: natural selection and what he described as "conditions of existence," which today we would call "environment" (p. 2).

They go on (pp. 34–35):

> In all the controversies over what the causes of diversity might be, no-one seems to have paid much attention to the factor in the environment that has the most obvious effect on any organism: food. A mutant that depends on a nutrient it cannot get is not "fit" and will not survive; nor will an established species if its essential food supplies run out. . . . Most evolutionists do not give nearly enough emphasis to this obvious truth. They would not deny it but they seldom see how important it is. The point which is missed is that food is not just food. The milk of different species is not interchangeable; its composition is uniquely tailored to each individual species' post-natal requirements. Cows' milk is very much richer in protein than human milk, but human milk is very much richer in essential fatty acids. Food contains a crucial "qualitative" element which makes possible various specializations within both the plant and animal kingdoms.

This means that the food we ate throughout evolution had some bearing on what we are today: "Nutrition will also play an important role in deciding our future" (Crawford and Marsh, p. 14). This seems so obvious that one wonders why anyone has bothered to write it down.

The pioneers of the organic movement could get quite worked up about this. Lady Eve Balfour, for example, wrote: "My subject is food, which concerns everyone; it is the soil, which concerns everyone—even if they do not realize it—and it is the history of certain recent scientific research linking these three vital subjects." She wanted this message to reach "the legislator, politician, voter, tax- and rate-payer, farmer, gardener, veterinary surgeon, doctor, sanitary inspector, public health authority, school teacher, priest, Tinker, Tailor, Soldier, Sailor—in fact, the Citizen" (Balfour, 1943, p. 9).

This concept of health is truly revolutionary. It was revolutionary back in the 1940s and unfortunately it remains so today.

Why revolutionary? Because to give form, shape and structure to that concept we would have to alter fundamentally the way our civilization relates to the biological base of the planet. It is not difficult to see why it remains an unfulfilled concept and has not become a way of life. I fear it may not even exist anymore as a concept, waiting to be tested and developed. Sometimes, I think that it only exists now as a slogan or a semireligous chant. Nonetheless, because the early practitioners of organic farming tried to build a practical agricultural system with a concept of health in mind and upon the principles of sound nutrition, I will briefly review the underlying principles of organic farming and food.

Although organic agriculture is known both by the public and by experts for its avoidance of agrichemicals and its consequent environmental benefits, its genesis occurred before the explosion of the agrichemical revolution and before the environment had been heard of as an issue. Of course, there were fertilizers in the 1920s, 1930s, and 1940s, but Steiner in Germany, Müller in Switzerland, Howard and Balfour in England, Rodale in the United States and others were concerned with health and not simply with environment, and they paid more attention to building soil fertility and vitality through recycling nutrients within a more or less closed system than they did to the avoidance of mineral salts (Boeringa, 1980).

In the words of Lady Eve Balfour (1978, p. 19):

> These pioneers had one thing in common: they were what we should now call Ecologists. They all succeeded in breaking away from the narrow confines of the preconceived ideas that dominated the scientific thinking of their day. They looked at the living world from a new perspective — they also asked new questions. Instead of the contemporary obsession with disease and its causes, they set out to discover the causes of Health. This led inevitably to an awareness of wholeness (the two words, after all, have the same origin) and to a gradual understanding that all life is one.

Eve Balfour was a disciple of Sir Robert McCarrison, a pioneer of human nutrition who, having systematically observed many peoples and many diets, realized that there was a quality in the diets of the healthiest peoples that was absent from the least healthy: "that the food in all these diets is, for the most part, fresh from its source, little altered by preparation, and complete; and that, in the case of foods based on agriculture, the natural cycle is complete. Animal and vegetable waste-soil-plant-food-animal-man; no chemical or substitution stage intervenes" (Balfour, 1943).

Others reached similar conclusions and developed the concept that health was part of a continuum through soil, plant, animal and man, and that by recycling nutrients through this chain, productivity could be maintained over time and health could be enhanced at all stages. The principle that food should be consumed fresh, for the most part whole and subjected to little or no processing and to no chemical intervention at any stage, became a foundation stone of the international organic movement (Woodward et al., 1996).

For all the hype and ballyhoo about so-called "sustainable" or even "regenerative" agriculture, about integrated farming systems, about low-input systems, selected-input systems, or any other "systems" that are lumped under the name "alternative agriculture," as far as I can see organic farming is still the only modern agricultural production system that has been built from a concept of health and nutrition. Unfortunately, the organic movement seems to have forgotten about it. The only thing that has really been remembered is the prohibition of chemical intervention. For the most part there has been a concentration either on residues, pollution, and environment, or specific macronutrient differences. A small amount of relevant research has been undertaken, but investigation and development of this founding idea and revolutionary concept of health being at one with the health of environment, the welfare of animals, and the nature of processing, packaging and distribution, has been largely neglected.

Instead we have an "organic market sector," an international "organic industry" that believes it will be successful when organic Mars Bars are on sale throughout the world. We have the production of organic food for export, not local consumption; we have energy-expensive miles travelled by processed and packaged organic foods; in one example, raw materials are transported from the Caribbean and Africa, to be processed and packaged in Belgium before being retailed from England.

Of course, some individuals, groups, and organizations do not subscribe to this industrialization and globalization of organic agriculture, but we have to recognize that organic production has not been organized around the basic concept of health and nutrition. We have to ask why not. And if organic production was our best shot so far at integrating food production, nutrition, and health, what must we do in the future?

To start, let us recognize that the driving force of our society, our civilization, its organizing principle, is not the husbanding of primary resources but their exploitation in the pursuit of economic growth. Most of us now have only a distant relationship with the biological base of our planet. Yet those primary resources and our relationship with them mainly through the provision and distribution of food ultimately are the key to our well-being. Our history shows dramatically what happens when man loses touch with or abuses those resources. An analysis of this is graphically presented by Crawford and Marsh (1989) in the book I referred to earlier, which is subtitled *Food, Evolution and the Future*.

While it was the development of agriculture that spawned what we regard as the first civilizations, its mismanagement and overexploitation were probably responsible for their collapse. Destruction of tree cover and overgrazing are thought to have started the process of desertification, which hastened the loss of soil fertility, nutritional collapse, and climate change. These factors played a major part in the destruction of the great Middle Eastern and Mediterranean cultures.

Aristotle, for example, noted some of the earliest examples of climate change (this and the passages below from Plato are cited in Crawford and Marsh, 1989, pp. 194–200):

> The same parts of the earth are not always moist or dry, but they change according as rivers come into existence or dry up. And so the relation of the land to sea changes too, and a place does not remain land or sea throughout all time.

Plato described the scene in his own day in Athens:

> The Acropolis is quite bare of soil which was washed away in one appalling night of flood. . . . The soil washed away from the highland in these periodical catastrophes forms no deposit of consequence in other places, but is carried out and lost in the deeps. . . . You are left with something like the skeleton of a body wasted by disease; the rich, soft soil has all run away leaving the land nothing but skin and bone.

He contrasts this to an earlier period in Athenian history:

> But in those days the damage had not taken place, the hills had high crests, the rocky plains of Phelleus were covered with rich soil and the mountains were covered by thick woods. For some mountains which today will only support bees produced not so long ago trees that when cut provided roof beams for huge buildings whose roofs are still standing.

And most notably, he sums up:

> This, then, was the general nature of the country, and it was cultivated with the skill you could expect from a class of genuine full-time agriculturists, with good natural talents, an abundant water supply and a well-balanced climate.

This picture changed when the buoyant Greek society and culture moved into its expansionist phase, disregarded its husbandry, and sought to push outward through trade and conquest.

The same story can be told of Rome, but even more dramatically. Rome began as a nation of farmers but pursued growth, trade and wealth beyond its own and Italy's boundaries. At the height of its empire, Rome was unable to feed itself. Grain was brought from as far as Spain and Britain and above all from North Africa. Half a million tons of grain a year were sent to Rome from North Africa. But the farmers either knew little or had forgotten the principles of soil husbandry, and as trees and ground cover were cleared, the topsoil and its fertile mineral supply were washed away. Harvest failures became frequent. Rome itself became full of unemployed people living on a dole of bread, olive oil, and wine, and it was no longer possible for ordinary people to make a living off the land.

During the protracted struggle to hold on to its empire, Rome one by one lost its sources of supply and was hindered by the increasing difficulty of getting crops off the great North African wheat fields as their topsoils degenerated and harvests failed. The elaborate Roman engineering and infrastructure of roads, aqueducts, and storage tanks were no real substitute for a sound environment. Eventually Rome, having outstripped its resources, was severed from its food supplies by a simple blockade of the Tiber, and fell in a week (Crawford and Marsh, 1989, pp. 201–202).

Is this history or current affairs? What are the key characteristics in the decline

and destruction of these great civilizations? And are there any similarities with today?

What about overstretched food supplies? In recent years the world's food stocks have fallen to the lowest level on record: 48 days supply, in comparison with the previous low of around 60 days (Kleiner, 1996). Total grain production in 1995 was 6% below its 1990 peak, and per capita production was down 13% (U.S. Dept. of Agriculture, 1996).

A projection of world food supply and demand over the next 35 years suggests a deficit of around 600 million tons of grain on the world market, roughly the entire current grain consumption of the United States and China, and about three times the total of world grain exports today. "Deficit" is a polite word for starvation.

What about overstretched water supplies? Some of the main grain-producing regions, such as the southern Great Plains in the U.S., the North China Plain, and the Indian Punjab, depend on underground water reserves, which are now falling and in some regions are close to depletion. The capacity of rivers to provide more water for irrigation, for instance in the Central Asian Republics and the Colorado River Basin in the U.S., is at or close to its limit, not least because of the increased demand for water from towns and industry. There is a compelling view that one consequence of global warming will be that grain-growing areas will suffer drought (Brown and Kane, 1995).

What about the loss of fertile land? The world grain-growing area declined from 735 million ha in 1981 to 695 million ha in 1993; in China it has been reduced by one-tenth from its 1976 peak, and the current annual decline of 1% is expected to continue. All the industrializing countries are losing agricultural land rapidly; in Japan and South Korea, it has fallen by one-third since 1960 and 1977, respectively. Much of the agricultural land that so far has been spared from urbanization is subject to erosion and salination. Around 30% of irrigated land suffers from moderate or serious erosion (Brown et al., 1994). A World Bank (1992) report on four developing countries (Costa Rica, Malawi, Mali and Mexico) indicates that annual losses of agricultural productivity due to soil erosion are equal to 1–1.5% of their gross domestic product.

And of course what about climate change? The International Panel on Climate Change (1990) tells us that merely to prevent any further increase in atmospheric carbon dioxide, which is already more than enough to drive global warming, would require an immediate 60% cut in emissions.

What about the separation of the land and production from the produce-consuming community, and the emphasis of production for commodity trading, not for food? Overall, Western Europe consumes nutrients from nearly five times its agricultural area. Most is in the form of animal feed, going mostly into intensive factory farming of pigs and poultry products (Tansey and Worsley, 1995).

Commodity trading is critical in today's world food system. No more than fifteen transnational corporations account for the bulk of this activity, with only six (five of them privately owned) dominating. They account for 90% of trade in pineapples, 65% of bananas, 85% of tea, 90% of cocoa beans, 70% of rice, 85% of coffee, 85% of corn, 60% of sugar, 85% of wheat.

It is instructive to look at the operations of one of these, Cargill, to see how it has positioned itself to be feed supplier, banker, buyer of finished cattle, butcher and wholesaler—everything but the farmer. The Cargill policy is to maximize the return on low-priced commodities by operating at three strategic levels: it trades grain internationally and, therefore, buys as cheaply as possible; it adds value to that cheap grain by using it as raw material for livestock feed, which it markets globally; then as a buyer of finished cattle, it adds further value by turning it into meat and meat products, again on the global market (Tansey and Worsley, 1995).

I admit to stretching the point in places, but I believe there is an alarming similarity between the relationship our civilization has with its resource base, its agriculture, its food system, and the relationship that those destroyed civilizations had with theirs. And I believe we have come to this dire situation for the same reason.

In the drive for greater and ever expanding economic wealth and well-being, we have ignored the limitations set by our environment and have become abusive toward and divorced from civilization's biological base. It is an agonizing contradiction that the pursuit of economic growth has brought unrivalled wealth but has set us on a treadmill from which it seems almost impossible to escape. We have to achieve an ever-increasing rate of economic growth to pay for the society we have. This is getting more difficult to do. And because growth means consumption, the more successful we are, the more we deplete and pollute the planet's resource base.

Let us briefly consider whether growth and consumption really can continue at the rate that is required over the long run. Economic growth is measured as Gross Domestic Product, GDP. The critical rate of growth, which is around 2.75% per year, say, if sustained over 100 years would give us an economy 15 times the present size. Each household consuming up to 15 times the number of—what? Miles of car travel? Household furnishings? Hamburgers? Hours negotiating with divorce lawyers? There may be some very costly pastimes in the future, such as trips to the moon and back, but skepticism about whether this will produce the necessary economic growth is justified—not least because a ceiling to consumption could be set long before then by the limited endurance of the environment.

There are those who will say that this kind of thing has been heard before. Indeed, there have been many instances of industries at their limits where remarkable ingenuity has been shown in developing alternatives. Someone cried "wolf," but the wolf did not come. But there are two morals to the tale of the wolf. The first is that you should not cry wolf too soon; the second is that, eventually, the wolf comes, and you should not allow your judgment to be jaded by all the false alarms.

The limits that are now visible deserve serious attention. They can be seen in the rural areas and in the towns and cities of both the developed and developing world. One has to be extraordinarily optimistic or ostrich-like not to recognize this.

Taking action is another matter. I find it hard to disagree with the conclusion of Meadows et al. (1992) that major changes in population control, reduction in industrial output, and the intensive development and application of technology for pollution abatement, improved land yield, soil protection and resource conservation must be implemented before 2015 to avoid a structural breakdown in the global economy around mid-century (Woodward et al., 1996).

There is a pseudo-Chinese proverb that says "if you do not change direction you will end up where you are going." The direction I would like us to take was suggested by Fritz Schumacher (1973) in *Small is Beautiful*. We should seek to replace our growth- and consumption-based economy "by evolving a new lifestyle, with new methods of production and new patterns of consumption: a lifestyle designed for permanence." This lifestyle must be built upon the principle of limitation, "because the environment in which it is placed is strictly limited." It must only employ methods and equipment "which are cheap enough so they are accessible to virtually everyone; suitable for small-scale application; and compatible with Man's need for creativity." Out of these three characteristics "is born nonviolence and a relationship of Man to nature which guarantees permanence."

Schumacher gave three "preliminary examples" of activities that could make significant contributions to the evolution of a world of "Peace and Permanence." The one he was most associated with was intermediate technology, "technology with a human face," as he called it. Another was new forms of partnerships, even common ownership. But the example he gave first was organic farming.

Those characteristics of organic farming that arise directly from the aspirations of its founders—self-regulating metabolic cycles tending toward closed systems, the use of local resources, the reduction in the use of fossil fuel, the employment of appropriate technology, and the use of decentralized systems for production, processing and distribution—seem to me to be the best way to respond to the environmental, economic, and social collapse of which this planet is on the brink (Woodward et al., 1996). They are also the characteristics that are most likely to ensure the introduction of health and nutrition into food production.

Is this romantic nonsense? It is easy to dismiss it as such, but it does make sense for several realistic and practical reasons:

- More than any other economic sector, agriculture, if practiced organically, can produce efficiently within the limits of a finite and fragile ecosystem.
- All signs point to a future where primary goods such as food and primary resources such as soil and water will be scarce and vulnerable. An economic sector such as agriculture that produces one and conserves the other can lead the way to wider economic and social well-being.
- The monolithic and undemocratic global economy has been found wanting on many counts; future economic development should be based on ecologically appropriate regions, which should enable essential goods and services, in particular primary goods such as food, to be supplied equitably to all.
- In the era before the market economy, reciprocal obligation within a fairly immediate level of local and regional community provided a powerful driver for maintaining social cohesion by being an integral part of the economic and social structure. This requires an active participatory economic democracy, which becomes less effective beyond the borders of a shared regional culture.
- Local processing of organic produce can be a source of wider economic and social development, showing the way for the evolution of a strong internal regional market that in turn can form the basis of appropriate trading relationships with other regions, even on the international level (Woodward et al., 1996).
- Organic agriculture, even with its faults, is still the only modern agricultural system that recognizes nutrition and health as goals of production.

There are examples in both the developed and developing world where these ideas are being put into practice. In the Dominican Republic, a long-standing project has revitalized a rural area by first reclaiming land and then producing food organically (Feedman, 1993). Passing on the skills to grow food led to wider education and to tackling issues of gender, health care, and decisionmaking structures. By the effort of seeking to produce food for themselves, the community found its way from achieving food security to developing a local economy that could build houses, bring in a modest outside income from selling surplus produce, educate its own children, and train people from other villages, all within a socially equitable community democracy using local ecological resources.

The approach also has relevance to the developed world. In the German state of Hesse a program has been initiated with the specific goal of using organic agriculture as a mainspring of regional development. It links farming, on-farm or local processing of regionally grown organic produce, and other economic initiatives such as tourism and community composting; the goal is to enable the farmer to take on the role of "regional developer" and so again become an essential part of the region's economic, social, and cultural life. Hesse is using various governmental and European Union schemes for training, product innovation and marketing, as well as cultural and landscape development. All this is done with the aim of adding value to primary products within the region and so creating employment and a strong regional economy in an environmentally appropriate way (Woodward et al., 1996).

The nutritional and health status of society is a consequence and a reflection of its driving force; the system of food production is one part of that driver. In a growth- and consumption-driven civilization, to quote Dennis T. Avery of The Hudson Institute, "people are not content with the low quality protein from vegetable sources. . . . In every country where incomes are rising, demand is rising rapidly for cooking oil, pork, fed lamb, eggs, poultry and other resource-costly foods that provide higher quality protein." He does not say cheaply and therefore intensively, but that is what he means (Woodward, 1996). Nor does he mention the "Western diseases" that result from this "Western" diet; heart disease, diabetes, cystic fibrosis, hypertension, liver disease, obesity, and cancers. I do not believe the world can afford for much longer anything that is so costly in environmental and human resources.

This talk might seem to lean toward the messages of gloom that are generally given by the joyless ones who leave you thinking that you would rather stick with the current mess than share any society they would create. Yet much in my message is optimistic and is based on the belief that if we face up to things we can tackle them. To emphasize this and to place myself in the ranks of the joyful and sanguine, I will end by citing three "proverbs" that are often quoted by the eminent U.K. agricultural scientist Sir Colin Spedding (1996, pp. 251–254),

- He who asks a question may look foolish for a short time; he who does not, may look foolish for the rest of his life.

- A peasant will stand for a long time on a hillside with his mouth open before a roast duck flies in.

And finally:

- We cannot predict the future; we can do better than that, we can invent it.

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Three New Sustainable Agriculture Web Sites Are Launched

Three new World Wide Web sites have been launched by the Wallace Institute, the Sustainable Agriculture Network, and the new Sustainable Farming Connection.

The Wallace Institute: The Wallace Institute's new Web homepage [http://www.hawiaa.org] features a description of the Institute and its agenda of leadership, policy research, and information; some of the site is still in progress. The site lists and will soon have information links to the Institute's programs: Policy Studies Program, Agriculture Policy Project, Ward Sinclair Memorial Internship, and Education Outreach. *Alternative Agriculture News* is available at the site, which will also soon include information about and summaries of additional publications: *American Journal of Alternative Agriculture*, Policy Studies Program Reports, Occasional Papers, Annual Reports, and the Henry A. Wallace Annual Lecture. Visitors to the homepage can e-mail messages to the Wallace Institute directly through a link at the site.

Sustainable Agriculture Network: SAN's new Web homepage [http://www.ces.ncsu.edu/san/] features information about sustainable agriculture, including on-line books, a database of more than 1,000 research projects funded by the Sustainable Agriculture Research and Education program, the Sustainable Agriculture Directory of Expertise, information about SARE grants, sustainable agriculture links to other sustainable agriculture Web sites. Visitors can search SAN's publications and media resources

Sustainable Farming Connection: Two former editors of *The New Farm* have launched the Sustainable Farming Connection [http://sunsite.unc.edu/farming-connection], an interactive Web site where farmers and others can find information about pro-duction, marketing, commentary, news, action alerts, archived materials, and links to other sites. Discussion groups provide a forum for farmers to ask questions, exchange tips, and share information. The Sustainable Farming Connection has been supported by the Wallace Genetic Foundation.

BOOK REVIEW

Tough Choices: Facing the Challenge of Food Scarcity. By Lester R. Brown. 1996. W.W. Norton and Company, Inc., 500 Fifth Ave, New York, NY 10110; http://www.norton.com. $11.00, paper. 159 pp

Ever since Thomas Malthus first made public his horrifying prediction that human population growth would eventually exceed increases in food production and lead to widespread famine, debates have pitted those concerned about resource conservation and ecological health against those convinced that free-market economics and human ingenuity will prevent disaster. Lester Brown's newest book, *Tough Choices: Facing the Challenge of Food Scarcity*, the third in a series from the Worldwatch Institute, takes a middle-of-the-road approach to analyzing the extremely important and controversial issues that define and surround the debate over population growth and food production. Brown's thesis is that food scarcity will be the first widespread manifestation of global environmental degradation. While innumerable books have been published on the topic, Brown's distinguishes itself from other recent ones in several ways.

First, it uses very current population growth and food production data from the USDA and FAO to analyze trends that have only begun to emerge in this decade. The analysis focuses on changes in global food production and food production per capita since 1990. Brown describes the book as "part of an ongoing debate" that the Worldwatch Institute has had with FAO and the World Bank over the prospects for global food production to meet demand over the next 15 years. According to Brown, FAO and World Bank projections of grain production are based on the assumption that yield gains achieved between 1950 and 1990 will continue beyond 2010. However, as Brown shows, global grain production patterns from 1990 to 1996 indicate a leveling off. Furthermore, Brown suggests that increasing affluence and industrialization, particularly in Asia, are leading to a greater demand for grain imports because of the desire for more meat and dairy in the diet and the loss of good cropland to urbanization. These trends, possibly combined with global environmental changes such as climatic warming, will lead to grain scarcity and higher prices and eventually result in global economic and political turmoil.

The second aspect that sets this book apart is its weaving together of ecological, economic, and political issues of food production to demonstrate their interdependence. Over the last several decades the economics and politics of global food trade have been dominated by surpluses and competition for markets. This is because capital and technology have been scarce while land, water, and labor have been abundant. According to Brown, this situation is reversing as land and water become limiting and the technologies largely responsible for yield increases since 1950, including crop hybrids and synthetic fertilizers, remain essentially the same. The effect on global trade already is evident. For example, the export price of wheat from the United States jumped from about $4 per bushel in early 1994 to over $7 in mid-1996. During the same period the European Union attempted to stem grain price increases in Europe by taxing exports. This resulted in higher prices outside Europe and largely canceled the positive effects of its food assistance programs to low-income populations of developing nations. This chain of events illustrates the complex interconnectedness of our global society and the far-reaching effects of agricultural and trade policies in wealthy, resource-rich nations.

Finally, *Tough Choices* differs from other works in its use of basic, qualitative logic to describe humanity's present dilemma and its simple, straightforward assumptions in predicting trends and proposing solutions. Brown's analysis does not depend upon sophisticated mathematics for either population growth or food production projections. As he states repeatedly, all predictions assume that 90 million people are added to the population annually. The variables he works with include direct or indirect grain consumption per capita, addition or loss of cropland, and limited yield increases in particular nations. The most important variable in this analysis is China's demand for imported grain. The rate of China's climb up the food chain as it industrializes has serious implications for the global supply and demand for grain.

To many people interested in alternative agriculture and food systems, Brown's suggestion that the global economic system is environmentally unsustainable is neither new nor controversial. However, his presentation and evaluation of current food production trends may provide the first solid indications that environmental degradation and population growth are beginning to harm the global economy. Interestingly, *Tough Choices* offers little discussion of the environmental and social consequences of agricultural industrialization and subsequent effects on regional food availability or on the prospects for alternative systems to alleviate food scarcity. Brown's global focus seems to neglect local solutions, perhaps because they seem far too radical in light of the immediate problems that humanity currently faces. The book ends with a cautiously optimistic tone, as other books on the topic generally do, and concludes by offering an array of short- and long-term solutions, some of which have been discussed by other authors in far more depth. Nevertheless, these suggestions provide food for thought for anyone interested in alternative food and farming systems. This book would be suitable as an up-to-date introduction to the economics and politics of global food production and trade and could serve as a reasonably priced stimulant for group discussion on agricultural sustainability.

Sean Clark, Department of Agronomy and Range Science, University of California, Davis, CA, 95616.

FROM THE EDITOR

American Journal of Alternative Agriculture has always striven to maintain high professional standards to ensure that its articles are always significant, authoritative, and reliable. To help us do this, an immense service is performed by the many people who volunteer their time to review submitted manuscripts. Besides advising us on whether a paper merits publication—whether it makes a valuable contribution and is technically valid—they also make many worthwhile suggestions to improve the quality of those papers that are accepted. We are very grateful for this invaluable assistance; to state it very simply, without it, this journal could not exist. It is a pleasure to acknowledge the people who have served as reviewers during the past five years.

William Lockeretz, Editor

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INSTITUTE NEWS

New Report Helps Readers Understand Pesticide Reduction

A new report from the Wallace Institute helps readers understand and evaluate the economic predictions in studies about restricting the use of, or reducing the risks from, agricultural pesticides. *The Myths and Realities of Pesticide Reduction: A Reader's Guide to Understanding the Full Economic Impacts*, by Edward Jaenicke, investigates the common themes in a diverse body of current research on pesticide economics.

The full implementation of last year's Food Quality Protection Act is likely to generate a new round of economic studies that attempt to predict the impacts on consumers and agricultural producers of the loss or restriction of certain pesticides, according to the report. It is also likely to rekindle a debate which centers on two premises: that the health and/or environmental risks of using certain pesticides may outweigh their economic benefits, and that using pesticides is not the only way to control agricultural pests effectively.

There are four reasons why studies on the consequences of pesticide reduction confuse or inadvertently mislead readers, according to the new report:

- Current studies often do not examine the benefits of pesticide reduction. Nonregulatory studies almost always focus only on the costs of pesticide reduction.
- Farmers usually learn to cope with new regulations through innovative adjustments. Most studies quote experts who predict that crop yields will decline when broad restrictions are imposed on pesticide use, ignoring the fact that farmers and pest-control suppliers can innovate with pest-control approaches.
- Current studies do not always put predicted costs in perspective. Statistics on the costs of pesticide reduction can be used misleadingly, when they could actually advance the cause of pesticide reduction.
- Current studies generally ignore the full range of policy alternatives. Economic impact research has focused largely on direct pesticide restrictions such as bans or cancellations.

The first step toward understanding studies on the impacts of pesticide reduction is identifying major issues that may be unclear to readers, according to the new report; the second step is to look at the assumptions that underlie the predictions made in those studies. Here is the report's checklist of questions to ask about those assumptions:

- How flexible are the pest-control policy mechanisms examined in the study?
- How far would the restriction shift policy from the status quo?
- How are the effects of pesticide reductions on yields calculated?
- How are researchers calculating the costs to consumers of farmers' efforts to reduce pesticide use?
- What role does international trade play in assessing the impact of pesticide reduction?
- Do researchers take into account where and how crops are grown as a result of pesticide reduction?
- How do researchers approach the issue of food quality?
- Do researchers ignore environmental-related benefits from reduced pesticide use?
- Do researchers ignore the production-related benefits of reduced pesticide use?

The report also makes recommendations for researchers analyzing pesticide reduction strategies who are trying to clarify the scope and inherent limitations of their work.

The Myths and Realities of Pesticide Reduction is $6 from the Wallace Institute, 9200 Edmonston Rd., #117, Greenbelt, MD 20770; (301) 441-8777; e-mail hawiaa @access.digex.net

Institute News continued on next page.

Merrigan Named to Facilities Review Task Force

The USDA has appointed Kathleen Merrigan, Senior Analyst at the Wallace Institute, to the new 15-member Facilities Review Task Force. The Task Force will recommend to Agriculture Secretary Dan Glickman and Congress priorities for agricultural research facilities in the next decade.

USDA Appoints National Commission on Small Farms

The USDA has formed a National Commission on Small Farms to study the problems of "the foundation of our rural communities," according to the USDA. Agriculture Secretary Dan Glickman directed the Commission to look at a range of problems and issues, including credit, risk management, education, and outreach, and to recommend improvements to better serve small and beginning farmers.

The Commission will also look at ways in which the USDA can ensure that small farms are treated fairly and have an equal opportunity to compete in vertically-integrated agricultural systems, and ways to encourage small farms to adopt farm operations and production practices, such as value-added cooperatives or direct marketing, that can help to improve their profitability.

"We must continue to find ways to help small and disadvantaged producers find ways to make a decent living, keep their land, and make their small farms economically viable," said Glickman.

Dr. Desmond Jolly of Davis, California, a member of the Wallace Institute's Board of Directors, is Vice Chair of the Commission. Dr. Frederick Magdoff, another member of the Wallace Institute's Board of Directors, is also a member of the Commission. For more information about the Commission, contact Jennifer Yezak Molen at (202) 690-0648.

Sustainable Ag Enters the Mainstream, Says Los Angeles Times

Once a "fringe notion," sustainable agriculture "is entering the agricultural mainstream, endorsed by big vintners in California, corn growers in Wisconsin, and truck farmers in Maine," according to a front-page article in *The Los Angeles Times* (July 21, 1997). "The reason: a spreading realization that the abundance resulting from the post-World War II push toward high-yield industrial agriculture has produced enormous consequences — in tainted ground water, depleted soil and shrinking farm towns." Sustainable agriculture, the article says, "favors techniques that preserve the environment and people's health while providing the nation's dwindling ranks of family farmers with a decent living and a reason to plow on instead of relinquishing their fields to agribusiness giants or housing developers."

The movement now includes approximately 5 percent of U.S. farmers who use sustainable practices — including the California vineyards owned by E&J Gallo Winery. The article prominently features Fred Kirschenmann, President of the Wallace Institute's Board of Directors, whose "innovations have won over many a reluctant ag advisor, researcher and farmer."

Wallace Lecture, Annual Report Now Available

"Second Thoughts on the Agricultural Revolution: Henry A. Wallace in His Last Years," the 1997 Henry A. Wallace Annual Lecture, and the 1996 Annual Report of the Wallace Institute are now available. The Wallace Lecture is $5, and the Annual Report is free from the Wallace Institute, 9200 Edmonston Road, #117, Greenbelt, MD 20770; (301) 441-8777.

Congress Maintains Funding for Sustainable Ag Programs

The U.S. Congress has approved final appropriations for Fiscal Year 1998 that maintain funding levels for most sustainable agriculture programs. A House-Senate conference is expected to meet in the near future to resolve the few differences between the House and Senate versions of the USDA appropriations bill. Here are the funding levels approved by the House and the Senate for several discretionary sustainable agriculture programs:

SARE: An $8 million appropriation was approved by both the House and the Senate for the Sustainable Agriculture Research and Education program, the same as last year.

SAPDP: A $3.3 million appropriation was approved by both the House and the Senate for the SARE (Chapter 3) Professional Development Program, the same as last year.

ATTRA: A $1.3 million appropriation was approved by the House for Appropriate Technology Transfer for Rural Areas, the same as last year; the Senate approved $1.5 million.

OFPA: A $500,000 appropriation was approved by the House for the Organic Foods Production Act, the same as last year; the Senate approved $1 million, the same amount President Clinton had requested.

In addition, funding for mandatory programs was "unscathed" and unchanged from the requested amounts, according to Ferd Hoefner of the Sustainable Agriculture Coalition.

CFO: A $15 million appropriation was approved for the new Conservation Farm Option, created to foster innovation in natural resource protection and enhancement.

EQIP: A $200 million appropriation was approved for the Environmental Quality Incentives Program, the same as the FY97 appropriation.

WRP: A $164 million appropriation was approved for the Wetlands Reserve Program, an increase from the FY97 appropriation of $119 million.

CFSA: A $2.5 million appropriation was approved for the Community Food Security Act, the same as the FY97 appropriation.

FRA: A $100 million appropriation was approved for the Fund for Rural America, the same as the FY97 appropriation.

Guide for Authors

The American Journal of Alternative Agriculture (AJAA) publishes original research on biological, physical, or social science aspects of alternative agriculture. We particularly welcome multidisciplinary studies, but papers from a specific discipline also are invited. However, since AJAA readership is much broader than for a single-discipline journal, highly specialized terminology should be explained or avoided. The significance of a statement, or the reasoning behind a conclusion, may have to be spelled out more than in a more specialized journal. See Vol. 5, No. 1, pp 2 & 3, for an explanation of the various categories of articles.

Units

Research papers should use the International (SI, or metric) system throughout. Occasional use of common unit equivalents in parentheses is permitted.

Title page

The title page should give the following information (all flush left): 1) title of the paper; 2) names of authors; 3) affiliation and office address of authors, and 4) disclaimers and publication number, if any. See examples in this issue of AJAA.

Abstract

The abstract should be 200 to 400 words suitable for readers from a broad range of disciplines. It should avoid highly-specialized terminology that might be appropriate for a single-discipline journal. Take particular care that the significance of the work is made clear, even to readers from a different field.

Key words

Provide subject matter key words suitable for use in scientific indexing.

Reference list

When citing material that has been covered in more than one format, such as the typescript of a conference presentation and a journal article, preference should be given to the version that is most readily available, and that is likely to remain so. Generally this means standard publication channels, such as books, journals, and regular government report series. Unpublished or informally-published material should be cited only when no alternative form exists.

References should be listed in alphabetical order by author's name, and by year for a particular author (with letters after the year if needed). If a sole author is also the lead author of papers with multiple authors, use the following order: single author (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized.

Citing references

Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

Footnotes

AJAA does not use bibliographic or substantive footnotes. All bibliographic references should be at the end of the text. Instead of substantive footnotes, include the material in the main text or consider eliminating it.

Manuscript preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Every figure and table should be mentioned at least once in the text.

A detailed guide to formatting is availabie from the editor (address below).

Submission of manuscripts

Submit four high-quality copies to William Lockeretz, Editor, American Journal of Alternative Agriculture, School of Nutrition Science and Policy, Tufts University, Medford, MA 02155. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form, that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of family farms and rural communities.

Alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, enhanced environmental quality, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Henry A. Wallace Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Wallace Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
- *A publisher of reliable scientific information on agricultural sustainability*

If you're interested in helping us, please contact the Henry A. Wallace Institute for Alternative Agriculture, 9200 Edmonston Road, Suite 117, Greenbelt, Maryland 20770-1551. Telephone: 301-441-8777; E-mail: hawiaa@access.digex.net; Web site: www.hawiaa.org

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